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Air force surveys in geophysics
No. 127

Investigations of ice-free sites for aircraft landings in East Greenland, 1959

Joseph H. Hartshorn
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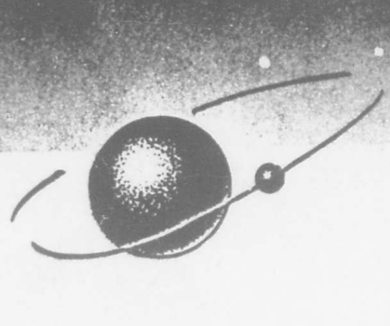
September 1961

GRD



GEOPHYSICS RESEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
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UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS

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INVESTIGATIONS OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN EAST GREENLAND, 1959

Joseph H. Hartshorn*
George E. Stoertz*
Allan N. Kover*
Stanley N. Davis**

September 1961

Project 7628
Task 76284

*U. S. Geological Survey
**Arctic Institute of North America

Terrestrial Sciences Laboratory
GEOPHYSICS RESEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
Bedford, Massachusetts

ABSTRACT

Thirty-three specific landing sites were investigated in the ice-free land area of East Greenland between Scoresby Sund and Loch Fyne. Eight of these are considered suitable for emergency landings in summer by heavy cargo planes, and several more for light cargo planes. Several sites were investigated for the Royal Greenland Trade Department in the Scorebysund - Kap Tobin area. A 1550-foot airstrip was located on a gravel terrace in the Jaettedal, eight miles northwest of Kap Tobin, and a short strip requiring some construction work was located near Kap Tobin. An 11,500-foot airstrip was tentatively laid out on a gravel terrace at Storelv, near Moskusoksefjord. Utilization of several of these sites can add a significant safety factor to commercial or military aircraft operations in East Greenland.

Reconnaissance observations verify the presence of abundant emergency sources of fresh water in East Greenland; analyses of 36 samples indicate water of good to excellent chemical quality.

INVESTIGATION OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN EAST GREENLAND, 1959

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ILLUSTRATIONS

PART I. INTRODUCTION

by

Joseph H. Hartshorn
United States Geological Survey

INVESTIGATIONS OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN EAST GREENLAND, 1959

PART I. INTRODUCTION

The U. S. Geological Survey, under contract to the Air Force Cambridge Research Center*, has conducted since 1955 terrain studies of northern and eastern Greenland for the purpose of locating potential natural emergency landing strips for aircraft. Preliminary photogeologic interpretation of areas in northern Greenland was carried out in 1955-1956 and in eastern Greenland as far south as Scoresby Sund in 1956-1957. Numerous airfield sites have been located that would be suitable for emergency landings with little or no preparation. Operation Defrost (1956), Operation Groundhog (1957), and Operation Groundhog (1958) included as part of their operations a detailed field survey and aerial reconnaissance of several sites in northern Greenland.

An extension of the air reconnaissance and preliminary ground survey is the investigation of one particular site and the final test landing of an aircraft on the unprepared or slightly modified strip. Operation Groundhog (1957) culminated in the successful test landing of an Air Force C-124 at Brønlund Fjord, Operation Groundhog I (1959) led to the successful landing of an Air Force C-130 at Polaris Promontory, and Operation Groundhog (1960) resulted in the landing of a C-130 at Centrum Sø. These final steps in the program of aerial photo interpretation, aerial reconnaissance, and field investigation have shown that in numerous areas of the Arctic it is possible to find ice-free natural landing areas that can support heavy cargo planes. The preliminary steps in this direction have been taken in this investigation of ice-free sites for aircraft landings from Kap Tobin to Loch Fyne in East Greenland carried out under Groundhog III (1959).

Ice-free land research is part of the Air Force Cambridge Research Center Arctic Terrain Research Program, Project 7628, Task 76284. It is a cooperative program between scientists of the Air Force Cambridge Research Center and the U. S. Geological Survey under Air Force contract.

Both American and Danish authorities have noted the need for additional emergency landing fields in northern and eastern Greenland to supplement existing airfields at Nord, Mesters Vig, and elsewhere (Photograph 1). Groundhog III (1959), in addition to advancing general objectives set by previous Groundhog operations, had been asked by the

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* Now Air Force Cambridge Research Laboratories

Royal Greenland Trade Department to study specifically whether unprepared or hastily prepared emergency landing strips for supply and personnel recovery could be located near Kap Tobin, Daneborg, and Danmark Havn. The general objectives of the expedition, in addition to these specific requests, were to reconnoiter, investigate, and evaluate ice-free land areas on the east coast of Greenland from Scoresby Sund to Germania Land for use as emergency landing or air rescue airstrips. Site selection is based on suitability for 5000-foot runways that can be used with a minimum of construction effort, but field evaluations are based on suitability of the terrain for supporting a wide range of aircraft operations, for example: (1) landings by light aircraft in summer; (2) landings by heavy aircraft in summer; (3) landings by aircraft in winter; (4) suitability for hasty airfield construction; and (5) miscellaneous evaluations. Studies include general terrain reconnaissance, military and engineering geology, geomorphology, soil mechanics, permafrost investigations, and water resources.

Photograph 1. Aircraft operations in East Greenland and North Greenland are exemplified by this view of a commercial prop-jet Viscount on a snow-covered, unsurfaced airstrip at Mesters Vig. Increasing use of the northern airways by commercial and military aircraft and the abrupt and severe changes in weather common in this area have created a need for emergency landing areas to supplement existing airfields. Date: 9 September 1959.

Members of the East Greenland field party were:

Dr. Joseph H. Hartshorn, Geomorphologist, U. S. Geological Survey; Scientific Leader of East Greenland Party
George E. Stoertz, Geologist, U. S. Geological Survey; Deputy Scientific Leader of East Greenland Party
Allan N. Kover, Geologist, U. S. Geological Survey
Dr. Stanley N. Davis, Geomorphologist, Arctic Institute of North America
Lowell R. Satin, Geologist, Arctic Institute of North America
Ole Skaerbo, Civil Engineer, Greenland Technical Organization; Liaison officer for the Ministry of Greenland

The itinerary was:

18 July 1959	- Scientific party departed McGuire AFB, New Jersey
19 July	- Scientific party arrived Thule, Greenland
20 July	- Scientific party departed Thule via USS ATKA
15 August	- Scientific party arrived at the village of Scoresbysund
21 August	- Departed Scoresbysund after work on Kap Tobin and Jaettedal airstrips and reconnaissance in Scoresby Sund up to Schuchert Elv
27 August	- Arrived Mesters Vig; reconnaissance on Liverpool Kyst
29 August	- Departed for MacKenzie Bugt
30 August	- Arrived MacKenzie Bugt; reconnaissance along fjords and in Storelv and Loch Fyne areas
31 August	- Storelv party set ashore for site investigation
1 September	- Remainder of party departed for Mesters Vig on USS ATKA
2 September	- USS ATKA arrived Mesters Vig
4 September	- USS ATKA departed Mesters Vig for ocean stations without scientific party
7 September	- Storelv field party returned to Mesters Vig via Dornier (DO-27)
10 September	- Departed Mesters Vig for Reykjavik, Iceland
10 September	- Arrived Keflavik AB, Iceland
11 September	- Departed Keflavik, Iceland for return to United States

DESCRIPTION OF PROJECT OPERATION

Two operational phases were originally planned; these were to include (1) shipborne helicopter reconnaissance from Scoresby Sund to Germania Land, and (2) intensive site study at Saelsø, Germania Land. Unexpected heavy ice conditions and extensive damage to the ATKA prevented completion of these plans, but a modified version was successfully carried out within the limitations of the weather and the season.

Personnel on the shipborne operation were in two teams. Hartshorn and Stoertz generally comprised one team, and together made aerial reconnaissance of 12 of the sites. The remaining sites were covered by other geologists working in pairs, or in several cases, alone.

For aerial reconnaissance the rear door of the HUP-2 helicopter was removed and one geologist with maps, movie camera, K20 aerial camera, and 35 mm camera sat near the open door. This arrangement gave excellent views of the ground and allowed full opportunity for observation and photography. The other geologist occupied the co-pilot's seat in the front of the helicopter, where he had a very good overall view of the geology and could assist the pilot in navigation. Once an aerial reconnaissance of the proposed site had been carried out, those sites that seemed to be most promising were landed on, and the geologists disembarked for sample trials with the penetrometer, for digging holes, and for general brief soils investigations.

In this manner 23 sites previously selected from aerial photos were inspected and numerous landings were made by helicopter to further the impressions obtained in the air. At three sites thus reconnoitered, maps were made, proposed centerlines for runways laid out, and soils evaluations made.

The second phase of the operation was changed from Saelsø to the area between the head of Loch Fyne and Moskusoksefjord, the Storelv Site. The ATKA transported the scientific party from Mesters Vig to MacKenzie Bugt, and the geologists reconnoitered the ice-free land of the inner fjords on the voyage. When the ATKA arrived in MacKenzie Bugt, Stoertz and Hartshorn made a preliminary reconnaissance of two alternative sites, Loch Fyne and Storelv. Loch Fyne was found to be unsuitable for an unprepared airstrip, and attention was focused on the Storelv Site. The Storelv field party, consisting of Stoertz (Storelv Party Leader), Davis, Skaerbo, and Satin, were transported by helicopter about 25 miles from the ATKA to the campsite. Hartshorn and Kover joined the party for the first full day in the field to help get as much preliminary survey work done as possible. Camping gear, scientific instruments, and rations were ferried ashore by the ATKA-based helicopters.

The full field party landed early on August 31. The first necessary detail was to locate a small airstrip approximately 660 feet (200 meters) in length for the Dornier (DO-27) to land on about a week later in order to evacuate the Storelv party of four men and their equipment. Two strips were quickly located. One, about 850 feet long on the west bank of the Storelv, was on a dissected sand and gravel terrace about 15 feet above the stream. The airstrip that was actually used was on the east bank of the Storelv, on a lower terrace, and was 750 feet long. On the latter strip, flags were laid out to delineate the runway for the Dornier pilot.

While several of the party set up the campsite, looked for short strips, or made a general reconnaissance, Hartshorn and Satin used a helicopter to investigate the large, almost featureless terrace surface on which the proposed runway had been located by aerial photo interpretation. The helicopter was flown about 100 to 300 feet above the ground, and the geologists chose what appeared to be the best runway location, avoiding most depressions and lakes on the surface of the terrace. A preliminary centerline, two miles long, approximately northwest-southeast, was laid out with orange flags.

In the following week, though hampered by snow, wind, and low clouds, the Storelv party re-evaluated the location of the runway, studied the natural features of the proposed airstrip, made a topographic map of the strip, and began preliminary soil bearing strength evaluations and soil studies. Slope and microrelief, drainage, construction materials, water supply, and the amount of hasty construction necessary to make the airstrip usable for heavy cargo aircraft were studied.

SUMMARY OF SCIENTIFIC WORK

A 710-foot by 100-foot landing strip was located at the Kap Tobin Site, about four miles south of Scoresbysund. This site is considered to be the best location for construction of a short landing strip between Scoresbysund and Kap Tobin. A detailed topographic survey was made of an area approximately 1500 feet square, including the runway. Engineering and soils studies were completed at the same time. The soil bearing strength (shearing strength) was determined by work on a grid of control points with the Waterways Experiment Station - U. S. Army Corps of Engineers cone penetrometer. Investigation of surface and subsurface soil conditions included excavation of soil test pits, collection of soil samples for identification and laboratory determination of engineering characteristics, partial measurements of moisture content in the active zone, and ground temperatures. A surficial geologic map of the entire 1500-foot square was prepared by Davis and Satin. The proposed runway needs some modification of the existing surface before aircraft landings can be attempted. Hand labor, to remove numerous small boulders and large cobbles, and the use of dynamite to remove several very large boulders, would accomplish this purpose.

At the Jaettedal Site, a topographic map of the immediate vicinity of the runway, an area about 2400 feet by 600 feet, was completed during one day in the field. A 1550-foot by 100-foot landing strip was laid out, and detailed measurements of the soil shearing strength made. No geologic map was made because of the geologic homogeneity of the site. The soil was examined in a pit dug at the south end of the runway and in the cutbank along the edge of the present glacial stream that actively occupies the valley of the Jaettedal. Soil temperatures, grain size of the materials, and a preliminary soil-type identification were obtained. The proposed 1550-foot strip needs no modification to permit the landing of light, wheeled aircraft.

Hasty soil strength tests were made along the centerlines of two strips in the same landing area about one mile north of Scoresbysund - the Hvalrosbugt Site. The strength of the natural soil surface here is very high, and the site is presently used by light planes landing at Scoresbysund.

At the Storelv Site, the field party located and marked an 11, 500-foot runway centerline, marked by orange flags at intervals of 500 feet. A detailed topographic survey, approximately 12, 000 feet by 500 feet, covers the runway site. Measurements of thickness of vegetation and silt on the surveyed runway centerline were made at 116 stations spaced 100 feet apart. Investigation of soil conditions on the surface and in test pits included partial measurement of soil strength, collection of soil samples for identification and laboratory determination of grain size distribution, plastic limit, liquid limit, and plasticity index, ground temperatures, moisture content determinations, and depth to frozen ground. Three alternative sites were located and hastily investigated. The major surveyed runway is considered suitable for hasty construction.

Scientific observations of the glacial geology of the area between Scoresby Sund and Loch Fyne were carried out at every available opportunity. Special note was taken of the marginal geology of the numerous valley glaciers over which the helicopters flew; aerial photos were taken of those that seemed to add to our general knowledge of the marginal stagnation of ice masses. Of particular interest are the "Many Lakes Glacier" and Schuchert Glacier in the Schuchert Elv, Charcot Glacier on Milne Land, Polhem Dal on Lyell Land, and the eskers and pitted stratified drift between Moskusoksefjord and Loch Fyne. The distribution of pingos and mud volcanoes was mapped.

PHYSICAL FEATURES OF EAST GREENLAND

The coastal area of East Greenland is a complex of glaciated mountain highlands and fringing lowlands separated by wide sounds and narrow fjords. Much of the lowland area has been modified by the deposition of materials washed out beyond the glacier, if not actually covered by the glaciers themselves, with the resulting cover of clayey or sandy till.

A number of small Greenland settlements cluster near the mouth of Scoresby Sund. The village of Igterajivit occupies a small raised marine bench at the mouth of Hurry Fjord. The settlement of Scoresbysund is in the northeast corner of Rosenvinge Bugt, and the wireless station, Kap Tobin, is about four miles south of Scoresbysund on a small peninsula projecting out into Scoresby Sund.

The Kap Tobin area is composed almost entirely of bedrock, primarily gneisses and schists, with a thin sandy till cover. The proposed airstrip at Kap Tobin is located on till that has been reworked by marine agencies, and in part reworked by frost action of post-marine time. Several lateral marginal drainage channels are present above the proposed strip, and two marine terraces carved out of till are present at approximately 40 to 48 feet above present high tide.

About a mile north of the village of Scoresbysund a small abandoned outwash plain, in places no more than four feet above the present active glacial stream, provides a landing strip for light aircraft. A Dornier (DO-27) employed by the Nordisk Mineselskab A/S has landed there many times.

Farther west, along a major stream draining southward from the Roscoe Bjerge, the Jaettedal strip is the largest natural airstrip that has been found in this area. The present glacier-fed stream has dissected an extensive stream deposit of sandy pebble and cobble gravel laid down at a slightly higher level. The present stream has not occupied this upper terrace for some time, as shown by the layer of weathered eolian sand that covers the outer or westward part of the terrace. One large segment of the dissected terrace has remained relatively intact and provides the space for the Jaettedal strip.

Just west of Hurry Fjord a high morainic deposit parallels the coast for several miles. Beyond this the coastal region is moderately low, and for the most part consists of horizontally bedded sands and very fine gravel, with lenses of pebbles and cobbles. These sand flats are apparently easily eroded, and the area almost as far north as Gurreholm Station is made up of this dissected plain. Just south of Gurreholm Station the coastal aspect changes, for here the rolling, rocky, morainic hills and lowlands reach down to Hall Bredning.

The western border of Jameson Land is the valley of the Schuchert Elv, a wide, anastomosing glacial stream fed from half a dozen valley glaciers, and extending from the Stauning Alps south for 32 miles to the head of Hall Bredning. Although the valley of the Schuchert Elv must have been occupied almost completely by a glacier at some time in the past, the postglacial work of the streams from the lateral valleys has obliterated most of the traces.

The east coast of Milne Land, a large island on the west side of Hall Bredning, is characterized by slopes that descend directly into the sea. Several flat areas occur in front of the two main glaciers that discharge eastward; one is the glacier that discharges its meltwaters into Charcot Havn, and the other is an unnamed glacier to the north. Both glaciers have extensive modern outwash in front of them. The northern glacier discharges into a bay. In addition to the modern glacial alluvial plain, there are dissected higher terraces about 60 to 80 feet above the modern plain. Charcot Glacier is characterized by modern glacial outwash in front of a well-defined terminal moraine, and behind the moraine by outwash that was deposited on ice and is presently being deformed, collapsed, and removed by the melting out of these buried masses of ice (Photograph 2).

The mountainous eastern coast of Jameson Land is indented with numerous fjords, in most of which valley glaciers descend to the sea. In the larger stream valleys that lead to the north, into Carlsberg Fjord and Fleming Fjord, for instance, there are many long, level areas that are suitable for investigation. In addition to the present valley bottoms, numerous dissected terraces are found at altitudes of from 15 to 50 feet above the present streams. Many of the valleys are broad and appear to have been little affected by valley glaciation. A remarkable set of pingos is present in the lower part of Ørsted Dal near its entrance into Fleming Fjord.

The Fjord Region of East Greenland begins at Kong Oscar Fjord and extends northward to Hold With Hope. It includes Traill Ø, Geographical Society Ø, and Ymer Ø, three large islands that are separated from the mainland of Greenland by deep fjords. Numerous peninsulas, nearly cut off by the waters of the fjords, extend eastward into the Fjord Region and include Lyell Land, Suess Land, Andrée Land, Gauss Halvø, and Hold With Hope.

The mountainous islands and peninsulas have similar topography. Ranges of rugged alpine mountains over 7000 feet high are found in some areas. Large plateau glaciers abound on the western peninsulas, whereas only minor glaciers are found generally on Gauss Halvø and the Hold With Hope foreland. As a consequence of vanished glaciers, many of the lowlands of the islands are composed of till, and the narrower valleys are filled with outwash, which in most cases has been trenched so that terraces exist above the modern streams.

Traill Ø has a nucleus of mountains on the western side, rising to over 6000 feet. A central lowland succeeds this to the east and is occupied by several rivers that run southward, eastward, and northward to the sea. At its eastern end the island consists of two mountainous peninsulas.

Photograph 2. View near Charcot Glacier. Slumped and pitted older outwash in foreground, deposited on and around blocks of stagnant ice; younger outwash in right background. End moraine runs diagonally across picture in left background. Charcot Glacier off to right. Elevation approximately 600 feet. Date: 20 August 1959.

Lyell Land, just west of Traill Ø, is composed almost entirely of high, glaciated mountains about 3000 to 7000 feet above sea level. One major valley, Polhem Dal,divides the peninsula from north to south. It is about 23 miles long and from less than a mile to over two miles wide. Valley glaciers once occupied it, as shown by the numerous kettle holes in the glacial outwash at the northern end of the valley and by the numerous collapse features scattered about the area. A raised delta, dissected by the downcutting of the stream since the land was raised above present sea level, is present on the eastern side of the peninsula. A deep steep-sided gorge has been incised about 30 feet into the bedrock beneath the delta.

Geographical Society Ø, separated by Vega Sund from Traill Ø, similarly is composed of a plexus of mountains at the western end, with a narrow low foreland on the side toward the Greenland Sea. The foreland has small mountains scattered across it, and the lowland is generally restricted to a belt from two to seven miles wide around the perimeter of the lower eastern mountains. Lack of large streams from the glaciated mountains on the eastern side gives rise to a till plain which has been untouched by streams, and hence is a rubbly, stony area. A few streams debouch from the mountains on the northeast side of the island and have built alluvial plains, outwash plains, and deltas.

Ymer Ø, bisected by a deep glacial valley, a fjord for nearly nine-tenths of its length, is really two mountainous ridges, with scattered plateau and ridge glaciers on the summits. The largest ice field is in the southwestern part of the island. A few small valleys have been carved in the mountains and debouch onto lowlands of till-mantled flats and gravel outwash plains.

North of Kejser Franz Joseph Fjord and its extension into Foster Bugt lies the largely unglaciated foreland of Hold With Hope and Gauss Halvø. Gauss Halvø is rugged and mountainous, bounded on the south by Kejser Franz Joseph Fjord and on the north by Moskusoksefjord. Numerous small glaciers exist on the peninsula, and the mountains extend down to the sea. One valley, the Paralleldal, cuts entirely across the peninsula from northeast to southwest.

South of Loch Fyne a lowland known in part as the Badlands, or Badlanddal, extends south to Foster Bugt. The northward draining sections of this lowland are composed of fine-grained sandy sediments, with clusters of pebbles, cobbles, and boulders, perhaps derived by marine action from the underlying till. To the south, the area is an intricately dissected series of gullied badlands, and near MacKenzie Bugt this gives way to a series of small lakes in swales between a series of concentric raised beaches.

Hold With Hope, the foreland east of Loch Fyne, is hilly to mountainous and includes one large lowland near Østersletten on the east coast. Numerous glacial streams and former glacial stream systems cover the area and provide lowland flats and terraces.

No comprehensive studies were carried on north of the southern end of Loch Fyne, although one reconnaissance flight did cover the forelands and some of the islands up to the Haystack on Hochstetter Forland.

PART II. AREAS OF LOW-LEVEL AERIAL RECONNAISSANCE AND HASTY FIELD INVESTIGATIONS

by

George E. Stoertz and Joseph H. Hartshorn
United States Geological Survey

PART II. AREAS OF LOW-LEVEL AERIAL RECONNAISSANCE AND HASTY FIELD INVESTIGATIONS

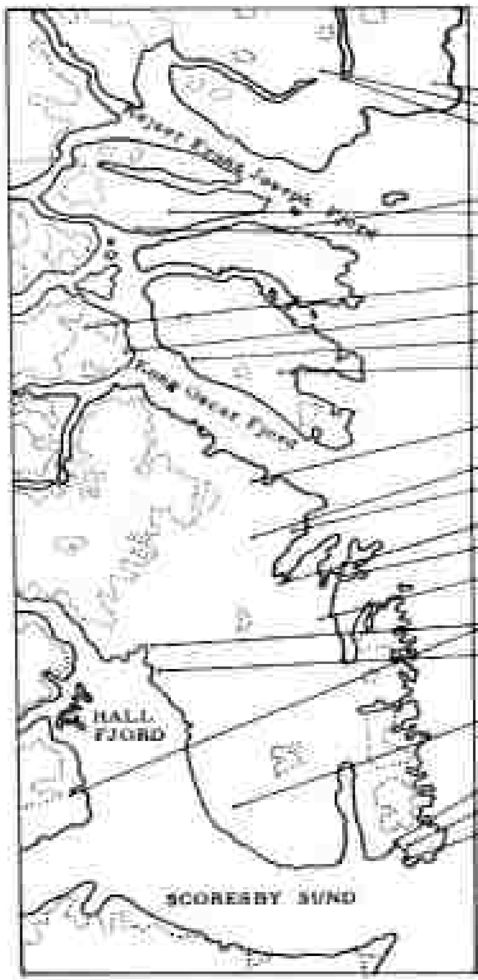
INTRODUCTION

All potential runways that were investigated in East Greenland during 1959 are shown on the index map (Fig. 1) and evaluated on Table 1. Of the 33 specific runway sites, eight are described in detail in the sections on the Scoresbysund area and the Storelv area. The remaining 25 sites are described in this section. Of these only the Nordøst Fjord Site was given more than a hasty ground reconnaissance or low-level aerial reconnaissance, and therefore that site is described in considerably more detail than the 24 others. Since the potential importance of these sites depends partly on their proximity to other landing areas, they are grouped by area in the following section.

The 25 runway sites are grouped into eight major areas of investigation. Within each of these areas the best sites for emergency aircraft landings in winter and summer have been selected and are recommended for use in case of emergency. Four recommended sites are so distributed that planes flying along the east coast of Greenland between latitudes 70°N and 74°N (from Scoresby Sund over Mesters Vig to Clavering Ø, a total distance of 300 miles) will at no point be more than 35 miles from a suitable year-round landing site. The distribution of these four recommended sites, plus the airfield at Mesters Vig, is shown in the following tabulation:

Landing site	Latitude	Longitude	Distance between sites
Storelv	73°39'N	22°02'W	
			65 statute miles
Southern Ymer Ø	73°03'N	24°37'W	
			59 statute miles
Mesters Vig	72°14'N	23°55'W	
			62 statute miles
Carlsberg Fjord	71°27'N	22°38'W	
			67 statute miles
Jaettedal	70°31'N	22°05'W	

The factors of distribution and proximity to other landing sites have been considered in evaluations of all sites. For example, the best known sites within large areas of 5000 square miles or more are considered especially valuable as emergency landing areas even if their suitability on an absolute scale is rated only fair. For this reason it is recommended that such areas as the Charcot Havn Site be used for emergency landings in winter if better sites are inaccessible.



KEY TO AREAS AND SITES INVESTIGATED
(for complete data refer to key numbers on Table 1)

Symbol	Site	Key nos.
× (4) ?	Daterslettes	25
● (4)	Storelv	24b
× (4) ?	Loch Fyne	24a
× (3) ?	Northern Geographical Society Ø	23
× (1) ?	Central Ymer Ø	22
● (5)	Southern Ymer Ø	21
×	Pollhem Dal	20
• (4)	Kirschdalen	19
× (5) ?	Western Traill Ø	17
• (1)	Eastern Traill Ø	16
× (3) ?	Eastern Scoresby Land	15
× (4) ?	Central Ørsted Dal	14
× (5) ?	Eastern Ørsted Dal	13
× (1) ?	Head of Fleming Fjord	12
×	Head of Nathorst Fjord	11
● (4) ?	Carlsberg Fjord	10
o (4) ?	Charcot Havn and vicinity	8-9
o (2)	Nordøst Fjord	7
×	Gurreholm	6
× (1) ?	Jameson Land	4-5
● (2)	Jaettedal	2
• (1)	Hestrushugt	3
× (1)	Kap Tobin	1

KEY TO SITE SYMBOLS

Suitability of unprepared sites for aircraft landings

SUMMER OR WINTER (Sites suitable for emergency landings in summer or winter)

- ● Large aircraft (suitable for emergency landings by cargo aircraft as large as a C-130 Hercules)
- • Small aircraft (suitable for emergency landings by aircraft as large as a DHC-4 Caribou)

WINTER ONLY o (Sites suitable for emergency landings when ground is frozen and/or snow covered)

UNSUITABLE × (Sites unsuitable or poorly suited for aircraft landings)

Recommendations

●• Mark site for possible emergency use (proximity to other sites is a factor)

××× Remove from further consideration as unprepared landing site (adjacent sites are superior or investigations to date show little or no potential value)

Length of unprepared landing sites

(approx. length of longest unprepared runway located in vicinity)

(5) 5000 ± 500 feet
(4) 4000 ± 500 feet
(3) 3000 ± 500 feet
(2) 2000 ± 500 feet
(1) 1000 ± 500 feet

Absence of number indicates no suitable runway was located in the area of investigation

Reliability of information

? Poor to fair reliability
Absence denotes fair to excellent reliability or not applicable

Figure 1. Index map showing areas of investigation, East Greenland, 1959.

SCHUCHERT ELV AREA

Natural Features

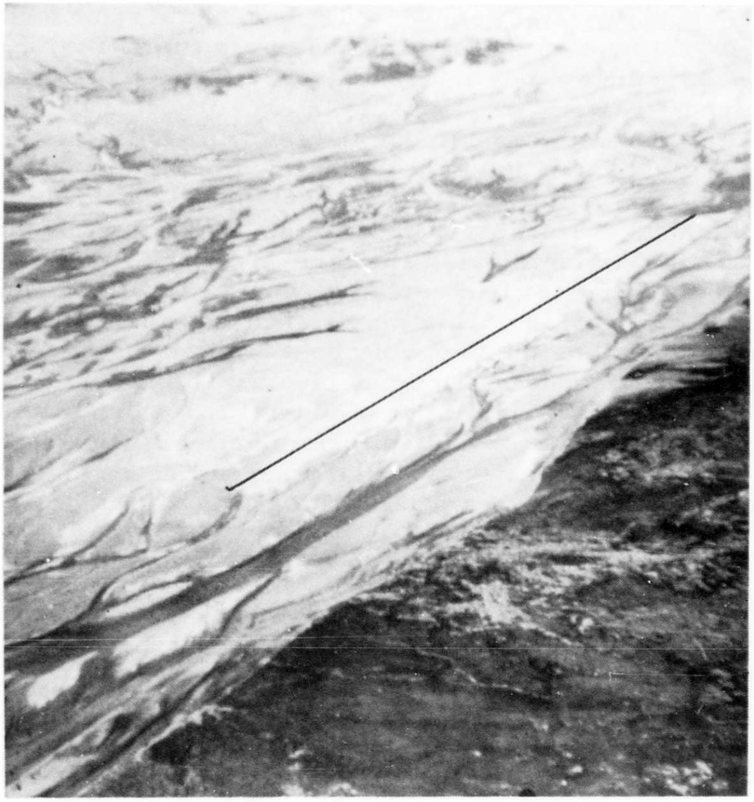
Schuchert Elv flows in a broad valley that separates Scoresby Land from northern Jameson Land. The valley trends north-south for a distance of about 40 miles; it is about 5 miles wide, and 2 miles of its width is occupied by the flood plain of Schuchert Elv, which is a braided stream fed chiefly by the glaciers of southeastern Scoresby Land. The valley is situated at the north end of Hall Bredning, which is the inner extension of Scoresby Sund; the two fjords together extend inland a distance of 100 miles from Kap Brewster. These two fjords together with Nordvest Fjord, their northwestern extension, form the longest fjord system in Greenland, extending about 240 miles inland from Kap Brewster. The mouth of Schuchert Elv is accessible by surface vessels during the summer.

Landing Sites Presently in Use

Three short landing strips have been constructed in the valley and are presently in use or have recently been used by a Dornier (DO-27) operated by the Nordisk Mineselskab A/S, Mesters Vig, in support of its molybdenum and lead prospects in the northern part of the valley. One strip has been bulldozed in the flood plain deposits of Schuchert Elv (Photograph 3) and another in a gap on the valley wall to the east, near latitude 71°48'N, longitude 24°18'W. The third strip is located on an alluvial fan on the west side of the valley, approximately at 71°35'N, 24°30'W.

Other Sites Investigated

In addition to a reconnaissance of the valley of Schuchert Elv an investigation was made of two specific landing sites that had been selected on the basis of a study of aerial photographs. These were the Nordøst Fjord Site (#7), located on the peninsula between Nordøst Fjord and Schuchert Elv, and the Gurreholm Site (#6), located east of the abandoned Gurreholm Station. These sites are shown on the index map (Fig. 1); complete data on investigations and evaluations of each are included in Table 1. During aerial reconnaissance the party failed to locate a favorable landing site in the Gurreholm area. Therefore it is recommended that the Gurreholm Site be removed from further consideration. A moderately detailed ground reconnaissance at the Nordøst Fjord Site showed that area to be poor to unsuitable for aircraft landings in summer, chiefly because of the presence of soil hummocks. Although the site is considered only fair to poor for aircraft landings in winter when the ground is snow-covered, it is the best landing site known within a radius of 45 miles in any direction from the site. Therefore results of investigations at that site are described in more detail below, and it is recommended that the site be used for emergency landings if better sites are inaccessible.



Photograph 3. Airstrip in the valley of Schuchert Elv. The bulldozed airstrip is 1500 feet long, located in the valley of the anastomosing Schuchert Elv. It is used by light planes of Nordisk Mineselskab A/S for support of geologic prospecting parties. Date: 19 August 1959.

Nordøst Fjord Site (#7)

Location. The site is 8 miles north of Gurreholm Station, on a limestone peninsula that separates Nordøst Fjord from Schuchert Elv. The site is on the west edge of the peninsula, approximately at latitude 71°21'N, longitude 24°37'W.

Accessibility. Accessible by ship from Nordøst Fjord; a steep cliff bordering the west side of the peninsula would hamper overland access from that direction. In other directions slopes are moderate, but Schuchert Elv would hamper access from the east.

Landforms and surficial geology. The peninsula is underlain by limestone (probably of Permian age) that crops out in the cliff along its west edge, which rises steeply to a height of several hundred feet above sea level. The highest part of the peninsula is near its west edge in the vicinity of the site. From the west edge the terrain slopes moderately downward toward the south and east to the flood plain and delta of Schuchert Elv, which appear to be composed largely of silt and fine sand. The delta at the head of Nordøst Fjord, immediately west of the site, is composed of similar material. The streams flowing over both deltas are fed by glacial meltwater and during summer carry large quantities of silt or clay in suspension. This material makes the surface of Nordøst Fjord murky for a distance of about 3 miles offshore, where the surface of the bay abruptly becomes clear. The limestone bedrock appears to be covered by a thin layer of glacial till which in turn appears to be overlain by a thick and uniform mantle of wind-deposited silt and fine sand. The layer of surficial unconsolidated material in the site area appears to be everywhere at least one foot thick.

Approaches. Unrestricted from the north and south, parallel to the only possible runway orientation.

Dimensions and orientation. The most suitable area is about 2500 feet long x 200 feet wide, oriented approximately N15°E. Extension to the south is limited by several large erratic boulders. Extension to the north is limited by a gradual steepening of slope.

Slope and microrelief. The surface is fairly flat, with one or two gentle rolls less than 5 feet deep within a horizontal distance of 200 to 300 feet. The surface is covered by soil hummocks 2 to 3 feet in diameter and about 6 inches high, separated by narrow depressions in which bare ground is exposed (Photograph 4). These hummocks would make any landing hazardous unless the tops of the hummocks were covered by at least 6 inches of snow, in which case ski-landings would be feasible. There is a possibility that strong winds considerably reduce snow cover on the site area in winter.

Photograph 4. Aerial view southward of the Nordøst Fjord Site (#7) from an elevation of about 100 feet. Soil hummocks hazardous to landings unless covered by at least 6 inches of snow. Large icebergs in Nordøst Fjord (right) and Hall Bredning (left) are visible in background. Date: 19 August 1959.

Soil characteristics. Soil strength is evaluated in Appendix I. Soil temperatures and moisture contents measured in a shallow test pit on August 19 are shown below:

Depth (inches)	Description	Depth (inches)	Average strength (cone index) bare area	vegetated	Soil temp. °F	Moisture content %
0 to 2	Vegetation and dead organic matter	surface	76	28	54	
		1	109	65		
2 to 12+	Wind-deposited mantle of silt and fine sand	2	124	106	49	15
		3	145	142		
		4	164	173		
		5	168	202		
		6	182	223	41	17
		9	209	268		
		12	259	305	38	23

Construction materials. Sand and gravel may be available from glacial outwash in the area between Nordøst Fjord and Margaret Lambert Sø, but transport would be difficult. Limestone is available from the cliff immediately west of the site.

Conclusions. In general the site is poorly suited for landing any type of aircraft during the summer because of insufficient length and the presence of soil hummocks 6 inches high. However in an emergency if better sites are inaccessible the wind-deposited mantle on the Nordøst Fjord Site is estimated to be sufficiently strong to support emergency landings by a C-130 cargo plane, provided that the landing strip was first either tested and marked on the ground or tested by aerial penetrometer. In winter when the soil hummocks are covered by at least 6 inches of snow the area is probably suitable for ski-landings by planes with ground runs up to 2000 feet.

Recommendations. It is recommended that the site not be used for aircraft landings in summer, but that it be used for emergency landings in winter if better sites are inaccessible.

SOUTHWESTERN JAMESON LAND

Natural Features

A low, gently sloping plateau, 10 to 30 miles wide, borders the southwestern coast of Jameson Land from Kap Stewart to Schuchert Elv. The plateau rises gradually from the coast to elevations of more than 1500 feet in the interior. The regional slope of the surface is only 2 percent, but it is dissected by numerous steep-sided stream valleys. These streams flow southwestard into Hall Bredning and Scoresby Sund. From the coast to a distance of at least six miles inland the surface appears to be underlain largely by stratified sand, containing occasional pockets or lenses of coarser debris. The surface is covered by a nearly continuous cover of tundra vegetation that is broken only in steep-sided stream valleys, in blowouts, and upland areas subject to wind erosion. The area is thought to be underlain by nearly horizontal beds of sandstone, sandy shale, and conglomerate of Jurassic and Triassic age, but no bedrock outcrops were noted during the aerial or hasty ground reconnaissance.

Evaluation for Aircraft Landings

Two general areas were investigated for possible landing sites; these were located inland (#4) and along the coast (#5). The principal areas of investigation are shown on the index map (Fig. 1). Complete data on investigations and evaluations of each area are included in Table 1. Hasty aerial reconnaissance of two specific areas as well as large areas in the vicinity showed little or no potential value for aircraft landings. Therefore the areas are not evaluated in detail here and it is recommended that southwestern Jameson Land be removed from further consideration for landing sites.

EASTERN MILNE LAND

Natural Features

Milne Land is a large island west of Hall Bredning and west of Jameson Land, situated midway between Renland and Knud Rasmussen Land. Along the east coast of Milne Land are two prominent embayments at the head of which are deltas and outwash plains. These have formed where streams of glacial meltwater enter Charcot Havn and the shallow bay two miles to the north. Each of the areas is approximately two miles wide and two miles long, apparently composed largely of silt and sand with lenses and stringers of gravel.

Evaluation for Aircraft Landings

The location of the areas is shown on the index map (Fig. 1, areas #8 and #9). Complete data on investigations and evaluations of each area are included in Table 1. The area west of Charcot Havn (#8) appears to contain a smooth area about 4000 feet long that is rated fair for aircraft landings in winter when the ground is frozen or snow-covered. The best area for that type of landing will vary from year to year as stream channels shift. Although rated only fair, it is the best landing site known within a radius of 45 miles in any direction from the site. Therefore it is recommended that the area be used for emergency landings in winter if better sites are inaccessible. The area north of Charcot Havn (#9) appears less suitable and is therefore tentatively removed from further consideration for aircraft landings. In summer the unvegetated active parts of both areas are considered unsuitable for landings by planes, even as light as a Dornier (DO-27). Inferred soil shearing strength of these areas is discussed in Appendix I.

HURRY FJORD AREA: SOUTHEASTERN JAMESON LAND AND LIVERPOOL LAND

Natural Features

Hurry Fjord extends in a north-south direction for 30 miles, separating southeastern Jameson Land from Liverpool Land. Liverpool Land is a peninsula east of Jameson Land, with a north south length of

80 miles and a width of about 20 miles. It is largely composed of Precambrian granite and gneiss; glaciers have eroded these hard crystalline rocks into a rugged mountainous landscape. The east coast is cut by numerous glaciers and short fjords, with steep slopes rising abruptly from sea level to a maximum elevation of over 4500 feet. Highest elevations are near the eastern coast and contain numerous jagged peaks, alpine glaciers, and permanent snowfields.

West of this rugged area moderate slopes predominate, and at slightly less than 2000 feet there are rolling plateaus with many rounded hills. The terrain descends moderately to the shore of Hurry Fjord, where there is a low coastal strip of unconsolidated deposits about one mile wide. Raised beach terraces are found up to elevations of at least 120 feet in this area. On the south a coastal lowland, in part underlain by relatively soft rocks of Jurassic age, borders Scoresby Sund and Rosenvinge Bugt.

Evaluation for Aircraft Landings

Possible sites for aircraft landings on the coastal lowland of southern Liverpool Land are described in detail in the section on the Scoresbysund area. In addition to a general reconnaissance of lowlands along the shore and at the head of Hurry Fjord, an aerial reconnaissance was made of one specific landing site that had been selected on the basis of a study of aerial photographs. This was the Kap Stewart Site (Fig. 1, #3), located near the mouth of Hurry Fjord in southeasternmost Jameson Land. Investigations of the Hurry Fjord and Kap Stewart areas, though incomplete, show little potential value for aircraft landings. Therefore it is recommended that the area be removed from further consideration for landing sites.

NORTHEASTERN JAMESON LAND

Natural Features

The northern part of Jameson Land is a rocky, hilly upland cut by wide, deep valleys most of which run northeastward into Carlsberg Fjord, Nathorst Fjord, and Fleming Fjord. The largest of these valleys is Ørsted Dal, a broad valley northwest of Fleming Fjord. The valleys are floored with unconsolidated deposits and contain several potential sites for aircraft landings, at least one of which (Carlsberg Fjord Site) appears to be a suitable year-round landing area. The region is largely underlain by nearly horizontal beds of sandstone and shale (Jurassic and Triassic age) interspersed with numerous horizontal layers of basaltic rock (diabase). Separating the major fjords in northeastern Jameson Land are several rugged peninsulas consisting of narrow, jagged ridges rising steeply from sea level to more than 2000 feet. The underlying rocks are of varying hardness, and jagged peaks and ridges are produced by differential erosion of alternating layers of hard and soft rock.

Evaluation for Aircraft Landings

Five areas were investigated for potential landing sites. These are located west of Carlsberg Fjord (#10), near the head of Nathorst Fjord (#11), at the head of Fleming Fjord (#12), and in Ørsted Dal (#13 and #14). The areas of investigation are shown on the index map (Fig. 1). Complete data on investigations and evaluations of each site are included in Table 1. The best landing site in the area is the Carlsberg Fjord Site (#10), which appears from a low-level aerial reconnaissance to be a suitable year-round landing area, situated midway between the airfield at Mesters Vig and the short landing strips near Scoresbysund. Therefore, results of preliminary investigations at that site are described in more detail below. It is recommended that investigations be completed on the ground and that the strip be marked for use in case of emergency. It is recommended that the two areas in Ørsted Dal (#13 and #14), though rated fair for emergency landings in winter, be removed tentatively from further consideration because of proximity to the superior site near Carlsberg Fjord. It is recommended that the areas near the heads of Nathorst Fjord (#11) and Fleming Fjord (#12) be removed from further consideration because investigations to date, though incomplete, show little or no potential value for landing sites.

Carlsberg Fjord Site (#10)

Location. The site is on an outwash terrace about one mile west of Carlsberg Fjord on the north side of the river that enters the fjord at latitude 71°27'N. Approximate location is 71°27'N, 22°38'W.

Accessibility. Generally accessible by surface vessel in late summer. Ships reaching Mesters Vig could commonly also reach Carlsberg Fjord. The site is one mile from the shore.

Landforms and surficial geology. The site is on a terrace of outwash gravel and sand estimated to be 40 to 80 feet above the river flood plain and delta that border it on the south. The surface of the terrace is exceptionally smooth and flat. It is covered by tundra vegetation that appears to have only a slight development of hummocks. If a thin mantle of wind-deposited silt or sand underlies the turf it is estimated to be only a few inches thick.

Approaches. Restricted by steep slopes both to the north and south. To the northeast, elevations about 200 feet higher than the runway lie on the flight path at a distance of about 8000 feet beyond the end of the runway, and elevations of 1000 feet lie a short distance west of the flightway. Approach from the northeast would skirt the east edge of the hillside, as shown by the view along the runway (Photograph 5), permitting a glide angle of about 1:40 (about 2 1/2 percent).

Approach from the southwest is practically blocked for large planes by the valley side that lies less than a mile beyond the end of the runway. Elevations of at least 1000 feet lie directly along the flight path one mile beyond the end of the runway, and elevations of well over 1000 feet lie a short distance east of the flightway. Approach by small planes would be possible from the west via the main river valley; approach from this direction would be assisted by utilization of only the northeast end of the runway.

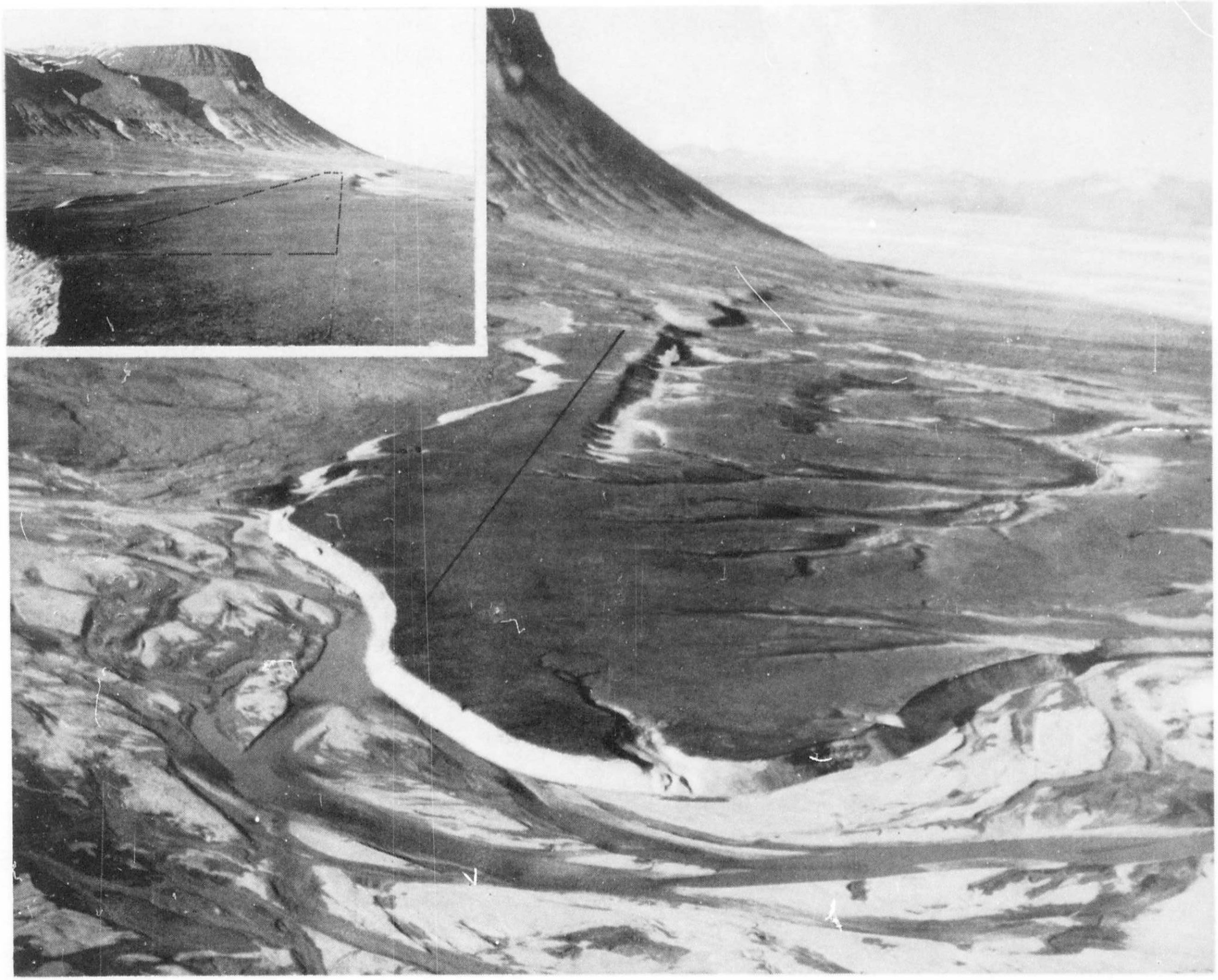
Dimensions and orientation. The best landing area is about 4000 feet long by about 200 feet wide, oriented approximately N30°E. Extension to the southwest is impossible because of a terrace scarp that drops 40 to 80 feet to the flood plain. The landing area could probably be extended an additional 1000 feet to the northeast by filling a gully.

Slope and microrelief. The surface appears smooth and flat, as shown by Photograph 5. Longitudinal slope is estimated to be less than 1 percent and overall slope less than 2 percent. Hummocks appear poorly developed and are apparently not an obstacle for any type of aircraft. One or two shallow swales may cross the runway 1500 feet from the northeast end, but these are not considered an obstacle for aircraft.

Soil characteristics. Outwash gravel and sand is estimated to lie within 6 inches below the surface. It is covered by a few inches of turf and possibly a few inches of wind-deposited silt and fine sand. The outwash should afford sufficient bearing strength to support heavy cargo planes such as a C-130.

Construction materials. Sand and gravel can be obtained from the terrace on which the site is located. Sandstone and shale can be obtained from bedrock outcrops one mile to the north.

Conclusions. The site appears to be a suitable year-round landing area for aircraft with ground runs up to 3500 feet long. However air approaches are only fair to poor (fair from northeast, poor from southwest) and crosswinds may be prevalent. The site is the best emergency landing area for large aircraft known in East Greenland south of Mesters Vig (lat. 72°14'N). Its location midway between the airfield at Mesters Vig and the short airstrips near Scoresbysund makes it well-situated as an emergency landing site for aircraft flying along the east coast of Greenland.



Photograph 5. Aerial views of the Carlsberg Fjord Site (#10), looking northward along a ridge of dissected valley fill, perhaps outwash gravel, located in valley on west side of Carlsberg Fjord. Centerline and outline of a potential 4000-foot runway are shown, oriented approximately N30°E. Date: 27 August 1959.

Recommendations. It is recommended that investigations be completed on the ground at the Carlsberg Fjord Site, including exact location and marking of runway and better evaluation of topography and soil conditions.

KONG OSCAR FJORD - MESTERS VIG AREA

Natural Features

Kong Oscar Fjord is about 90 miles long, trending in a northwest-southeast direction, and ranges from 5 to 15 miles in width. Traill Ø forms most of its northeast shore while Scoresby Land and Lyell Land form most of its southwest shore. Most of the landscape within 10 miles of Kong Oscar Fjord is dominated by rugged mountains and plateaus, with only minor lowland areas. Northernmost Scoresby Land and Lyell Land are characterized by rugged alpine topography with numerous glaciers and small icecaps. Elevations are predominantly from 2000 to 7000 feet above sea level. These mountains are composed largely of highly resistant crystalline rocks belonging to the Eleanor Bay formation (of Precambrian age). These rocks include crystalline limestone, quartzite, shale, and slate. Northwestern Traill Ø is also a steep mountainous area with most elevations ranging from 2000 to 5000 feet above sea level; the highest elevations are about 6200 feet. The mountains consist largely of highly resistant beds of sandstone and conglomerate (of Devonian age). The southeastern part of Kong Oscar Fjord (east of long. 24°30'W on the south shore and east of 24°15'W on the north shore) is bordered by moderately steep mountains, chiefly less than 4000 feet in elevation. These mountains are composed largely of sandstone and shale (ranging from Carboniferous to Cretaceous age). Southeasternmost Traill Ø consists of rugged mountains with peaks rising steeply to a maximum elevation of about 4350 feet; these are composed largely of granitic rocks.

Evaluation for Aircraft Landings

While the ATKA steamed through Kong Oscar Fjord a low-level aerial reconnaissance was made of most lowland areas within 10 miles of the fjord. All specific areas investigated in this region are within 40 miles of the airfield at Mesters Vig and therefore of marginal utility as emergency landing sites. Five areas were investigated for potential landing sites. These are located in eastern Scoresby Land (#15), eastern Traill Ø (#16), western Traill Ø (#17), Kirschdalen (#19), and Polhem Dal (#20), the last two being located on Lyell Land. The areas of investigation are shown on the index map (Fig. 1). Complete data on investigations and evaluations of each site are included in Table 1. The best landing site in the area is considered to be the Kirschdalen

Site (#19) on Lyell Land, which appears from a hasty ground reconnaissance to be a suitable year-round landing area. Therefore results of preliminary investigations at that site are described in more detail below. It is recommended that investigations be completed on the ground and that the strip be marked for use in case of emergency. Another suitable year-round landing area was located at the west end of Mount Norris Fjord in eastern Traill Ø (#16B). It is recommended that investigations at that site be completed on the ground if convenient. However, that site is of doubtful utility because it is located less than 30 miles from the airfield at Mesters Vig and only about 40 miles from the site at Kirschdalen, which is considered slightly superior. It is recommended that the three strips in western Traill Ø (#17) and the one strip in eastern Scoresby Land (#15B), though rated good to fair for emergency landings in winter, be removed tentatively from further consideration because of proximity to the superior sites at Kirschdalen (#19) and eastern Traill Ø (#16B), as well as the airfield at Mesters Vig. It is recommended that one of the strips in eastern Scoresby Land (#15A) and eastern Traill Ø (#16A), and the strip in Polhem Dal (#20), be removed from further consideration because investigations to date, though incomplete, show little or no potential value for landing sites.

Kirschdalen Site (#19)

Location. The site is on an outwash terrace on the south side of the river that enters Kong Oscar Fjord exactly 28 miles northwest of the airfield at Mesters Vig. Its approximate location is latitude 72°33'30"N, longitude 24°43'W.

Accessibility. Generally accessible by boat from Mesters Vig during the summer. The site is about 1000 feet from the shore of Kong Oscar Fjord.

Landforms and surficial geology. The site is on an outwash terrace about 150 feet above present sea level. The terrace is apparently composed of silt, sand, and gravel. The surface has a smooth cover of vegetation and slopes downward toward the east. The landing area is terminated on the north and east edges by a terrace scarp that drops steeply to the flood plain and delta of the present river.

Approaches. Air approach from the east is unrestricted over Kong Oscar Fjord. Approach from the west is restricted to the valley of Kirschdalen and would be at a grade of about 10 percent for a horizontal distance of three miles.

Dimensions and orientation. The proposed landing area is about 4500 feet long by about 200 feet wide, oriented approximately east-west. Extension either to the east or west is prevented by streams and terrace scarps.

Slope and microrelief. The surface is fairly smooth although a few shallow swales cross the terrace. Only two or three swales appear deep enough to be a possible obstacle to aircraft and would require further investigation on the ground to determine if they need some filling. A few boulders less than 2 feet in diameter may have to be moved, depending on exact location of the runway.

Soil characteristics. The surface is underlain by a mixture of silt and pebbles, with a thin cover of vegetation. There is a possibility that a thin mantle of wind-deposited silt or fine sand underlies the turf, as on many lowland surfaces in East Greenland. Surface strength is thought to be sufficient to support emergency landings by a C-130. Further investigations are necessary to determine shearing strength adequately, but it is estimated that if gravelly outwash lies within 5 inches of the surface the area will safely support heavier cargo planes such as a C-124.

Construction materials. Sand and gravel can be obtained either from the terrace on which the site is located or from the stream valley to the north and west.

Conclusions. The site appears to be a suitable year-round landing area for aircraft with ground runs up to 4000 feet long. However air approach from the west is only fair. The site is the best-known emergency landing area in the vicinity of Kong Oscar Fjord (excluding the airfield at Mesters Vig).

Recommendations. It is recommended that investigations be completed on the ground at the Kirschdalen Site, including exact location and marking of runway, and better evaluation of topography and soil conditions.

SOFIA SUND AREA

Natural Features

Sofia Sund is about 30 miles long and 2 miles wide, trending roughly east-west, and separating Ymer Ø from Geographical Society Ø. The walls of Sofia Sund rise steeply to elevations of about 5000 feet, and are composed almost entirely of resistant beds of sandstone and conglomerate (of Devonian age). The adjacent parts of Ymer Ø and Geographical Society Ø are characterized by mountainous terrain that is rugged and highly dissected into a series of ridges and V-shaped valleys. Slopes are steep and fairly uniform, but there are relatively few precipitous slopes except along the principal fjords. There are very few flat-topped plateau-like summits in this area, although many ridges and peaks are at uniform levels, between 4000 and 5000 feet above sea level. Summits tend to be ridge-like with few jagged isolated peaks. These areas of bedded rocks generally lack the wild alpine topography characteristic of crystalline rock areas to the west, with their isolated jagged peaks, precipitous slopes, and numerous alpine glaciers.

The only gently sloping areas of appreciable size, and the only areas of thick unconsolidated deposits, are limited to the lowland in the south-central part of Ymer Ø and a few narrow areas along the shore of Sofia Sund.

Evaluation for Aircraft Landings

While the ATKA steamed through Sofia Sund a low-level aerial reconnaissance was made of adjacent lowland areas on Ymer Ø and Geographical Society Ø. Three areas were investigated for potential landing sites. These were in southern Ymer Ø (#21), in central Ymer Ø (#22), and in northern Geographical Society Ø (#23). The areas of investigation are shown on the index map (Fig. 1). Complete data on investigation and evaluations of each site are included in Table 1. The best landing site in the area is the site in southern Ymer Ø (#21), which appears from a hasty ground reconnaissance to be a suitable year-round landing area, situated equidistant from the airfield at Mesters Vig and the landing area at Storelv. Therefore results of preliminary investigations at that site are described in more detail below. It is recommended that investigations be completed on the ground and that the strip be marked for use in case of emergency. It is recommended that the areas in central Ymer Ø (#22) and in northern Geographical Society Ø (#23) be removed from further consideration because investigations to date, though incomplete , show little or no potential value for landing sites.

Site in Southern Ymer Ø (#21)

Location. The site is on a gently sloping coastal plain about 2 miles east of the prominent delta in south-central Ymer Ø, at the juncture of Kong Oscar Fjord and Sofia Sund. Approximate location is latitude 73°03'N, longitude 24°37'W.

Accessibility. Generally accessible by boat from Mesters Vig during the summer. The site is about 1000 feet from the shore of Sofia Sund.

Landforms and surficial geology. The site is on a coastal plain that slopes gently northward from the shore of Sofia Sund at an estimated grade of less than 4 percent. The surface is covered by a continuous layer of tundra vegetation, apparently underlain by silt, sand, and gravel, probably deltaic in origin.

Approaches. Air approaches are unrestricted from either east or west, over Sofia Sund or the head of Kong Oscar Fjord, respectively.

Dimensions and orientation. Orientation is approximately east-west, parallel to the shore of Sofia Sund. The proposed landing area is approximately 5000 feet long by 200 feet wide, limited at both ends by shallow drainage channels; the landing area could be extended by filling these channels.

Slope and microrelief. The surface is fairly smooth, as shown by Photograph 6. A few very shallow swales cross the landing area and a few boulders less than 2 feet in diameter may have to be removed, depending on the exact location of the runway. Longitudinal slope is very low; transverse slope is estimated to be between 2 and 4 percent.

Photograph 6. Possible emergency landing area in southern Ymer Ø (Site #21). View east along the gently sloping coastal plain at the juncture of Kong Oscar Fjord and Sofia Sund. A few shallow swales cross the area and a few boulders are visible. Date: 30 August 1959.

Soil characteristics. Hasty penetrometer tests indicate that the strength of the upper 4 or 5 inches of soil is low, probably consisting largely of vegetation and silty sand. A thin mantle of wind-deposited silt or fine sand may be present. Within 6 to 8 inches below the surface the soil becomes coarser and the strength increases rapidly. During melt season, the surface is probably moist and softer. Bearing strength in late summer is estimated to be adequate to support emergency landings by cargo planes such as a C-130.

Construction materials. Sand and gravel are available from the stream valley located about 3 miles northwest of the site. Sandstone or conglomerate are available from bedrock outcrops located 2 miles northeast of the site.

Conclusions. The site appears to be a suitable landing area in winter or summer, but may become too moist and soft during, and shortly after, the melt season.

Recommendations. It is recommended that investigations be completed on the ground at the Ymer Ø Site, including exact location and marking of runway, and better evaluation of topography and soil conditions.

HOLD WITH HOPE AND VICINITY

Natural Features

Broad extensive lowlands occupy the southeastern part of Hold With Hope and the area between MacKenzie Bugt and the heads of Loch Fyne and Moskusoksefjord. The lowland of southeastern Hold With Hope is known as Østersletten. Much of the lowland topography of this area is hummocky, characterized by scattered low hills and poorly drained boggy depressions. These areas are principally underlain by glacial moraine, consisting of an unconsolidated, unsorted mixture of silt, sand, and gravel, containing scattered cobbles and boulders. Areas of relatively flat-surfaced outwash and alluvium are also present. The highlands in this area, including those of Hold With Hope and eastern Gauss Halvø, are composed largely of basalt (of Tertiary age). The lower slopes of the basalt mountains are characterized by parallel bedrock terraces defended by successive flows of basalt. Terraces of this type are found along the west side of Hold With Hope, bordering the broad lowland at the head of Loch Fyne. One of the outstanding features of that lowland is an exceptionally flat, emerged bottom-land that extends for a distance of several miles south of Loch Fyne (Photograph 7).

Photograph 7. View eastward across the broad lowland at the head of Loch Fyne. In the foreground is an emerged bottom-land that extends for a distance of several miles south of Loch Fyne, which can be seen on the left margin of the photograph. Elevation approximately 3000 feet. Date: 30 August 1959.

Evaluation for Aircraft Landings

In addition to a general aerial reconnaissance of the lowland areas, three specific areas were investigated for potential landing sites. These are located in the vicinity of Storelv (#24B), Loch Fyne (#24A), and Østersletten (#25). The areas of investigation are shown on the index map (Fig. 1). Complete data on investigations and evaluations of each site are included in Table 1. The best landing site in the area is the Storelv Site, which appears from a detailed field investigation to be a suitable emergency landing area for heavy cargo aircraft, subject to limitations caused by microrelief. Detailed results of investigations in the vicinity of Storelv are described in a separate section of the report. It is recommended that the Loch Fyne area (#24A), though rated fair for emergency landings in winter, be removed tentatively from further consideration for landings either in winter or summer because of proximity to the superior sites near Storelv. It is recommended that the Østersletten area (#25) be removed from further consideration because investigations to date, though incomplete, show little or no potential value for landing sites.

SUMMARY

Table 1 is a tabular summary of the most significant results of investigations of landing sites in East Greenland. Thirty-three specific landing sites were investigated in August-September 1959 between Scoresby Sund and Loch Fyne. Twenty-three of these were sites that had previously been selected by a study of aerial photographs, nine were located by reconnaissance in the field, and one was the existing landing site near Scoresbysund.

Three landing sites were evaluated by means of a detailed field investigation, three by a moderate ground reconnaissance, 13 by a hasty ground reconnaissance, and 14 by a low-level aerial reconnaissance. To summarize, 19 sites were investigated at least briefly on the ground while 14 were investigated from the air.

Landing strip lengths were determined in the field by taping or pacing at six sites, by timed flyovers via helicopter at five sites, and by less reliable means at the remaining 22 sites. The topography of landing sites was evaluated by detailed topographic mapping of three sites, by aircraft landing tests on three sites, by ground photographs in conjuction with hasty ground reconnaissance at seven or more sites, and by less reliable means at the remaining 20 sites. Soil conditions were evaluated by soil sampling and/or complete cone penetrometer tests at nine landing sites, by single cone penetrometer tests or depth of penetration of helicopter tail wheel at 10 sites, and by less reliable means at the remaining 14 sites. To summarize, evaluations of six landing sites are considered reliable, evaluations of 12 sites are considered fairly reliable, and evaluations of the remaining 15 sites have only a poor degree of reliability. However every known potential landing area between latitudes 70°N and 74°N with the exception of the Kap Stewart Site (#3 on Fig. 1) was investigated in sufficient detail to permit tentative conclusions concerning its suitability and tentative recommendations for its future use.

CONCLUSIONS

1. Eight landing sites are considered suitable for emergency landings in summer by cargo planes as heavy as a C-130. The remaining 25 sites are considered unsuitable or only poorly suited for this purpose.

2. Thirteen landing sites are considered suitable for emergency landings in summer by planes as heavy as a DHC-4 Caribou. The remaining 20 sites are considered unsuitable or only poorly suited for this purpose.

3. Twenty-four landing sites are considered suitable for emergency landings in winter when the ground is frozen and/or snow-covered. The remaining nine sites are considered unsuitable or only poorly suited for this purpose.

4. Nine landing sites are considered suitable for hasty airfield construction. The remaining 24 sites are considered unsuitable, poorly suited, or doubtful for this purpose.

RECOMMENDATIONS

A large number of factors affect recommended future use of the 33 landing sites that were investigated. Areal distribution with relation to probable flight paths and proximity to other sites are as important as evaluations of suitability on an absolute scale. These factors have been considered in the following recommendations. Detailed recommendations for the use of specific landing sites in the Storelv area and the Scoresbysund area are discussed in the appropriate sections of this report.

1. It is recommended that four sites be marked for use in case of emergency. These sites are the Jaettedal Site (#2), Carlsberg Fjord Site (#10), Ymer Ø Site (#21), and Storelv Site (#24B). Each of these

is the best-known landing site within an area of over 11,000 square miles (equivalent to a circle with a radius of 60 miles). At each site except the Jaettedal Site it is recommended that more detailed investigations be completed on the ground in conjunction with marking. The four recommended sites are so uniformly spaced between latitudes 70°N and 74°N that planes can fly a total distance of 300 miles along the coast without ever being more than 35 miles from a suitable year-round emergency landing site. Thus the utilization of these four selected sites can add a significant safety factor to commercial or military aircraft operations in a part of East Greenland where aircraft may now be as much as 120 miles from a suitable landing site.

2. It is recommended that investigations be completed on the ground at the Kirschdalen Site (#19) and that the area be given further consideration for use as a year-round emergency airstrip. However its proximity to the airfield at Mesters Vig would limit its potential value.

3. It is recommended that two specific sites in the Hall Bredning area be used for emergency landings in winter, but only if better landing sites are not accessible. These are near Nordøst Fjord (#7) and Charcot Havn (#8). Both of these areas are of marginal suitability, but are the only known landing areas longer than 1500 feet within areas of more than 6000 square miles. They are not recommended for use unless the ground is frozen or snow-covered and unless the superior sites mentioned above are inaccessible.

4. It is recommended that 20 specific sites be removed from further consideration for emergency landings, either because other sites in the vicinity are superior or because investigations to date, although incomplete, show little or no potential value.

PART III. INVESTIGATION OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN THE SCORESBYSUND AREA

by

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PART III. INVESTIGATION OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN THE SCORESBYSUND AREA, EAST GREENLAND

SUMMARY

In August 1959 a field party of five geologists and one civil engineer located and surveyed a 1550-foot airstrip on a gravel terrace near Scoresbysund, East Greenland. A subsequent test landing by a Dornier (DO-27) demonstrated that the natural surface will safely support that aircraft and will probably support landings by an Otter (DHC-3) or a Caribou (DHC-4). The field operations were staged from MSTS icebreaker USS ATKA and were supported by U. S. Navy helicopters. The Dornier aircraft was owned by the Nordisk Mineselskab A/S (Northern Mining Company), Mesters Vig. Other sites investigated in the vicinity included the landing site presently in use near Scoresbysund and a site near Kap Tobin that could be made suitable for emergency landings by light aircraft with a small amount of construction work.

INTRODUCTION

In 1958 the Royal Greenland Trade Department expressed a desire for landing strips of 660 feet (200 meters) or longer in the Scoresbysund area for use by planes such as the Dornier (DO-27)1/, the Caribou (DHC-4)1/, or the Otter (DHC-3)1/, in support of the Danish village at Scoresbysund and the Danish station at Kap Tobin, five miles to the south. During field reconnaissance near Scoresbysund in the summer of 1959 two possible areas were located within four miles of Scoresbysund, to the south and northwest of the village. Both areas contain potential landing sites that are suitable for light aircraft or that could be made suitable with a small amount of construction work. In addition the two landing strips located about one mile north of Scoresbysund, and presently in use by light aircraft, were investigated; that landing area is referred to in this report as the "Hvalrosbugt Site." The three sites are described and evaluated in the following sections of this report.

1/ The characteristics and airfield criteria for these planes are summarized in Table 2. A 770-foot landing strip would be suitable for emergency landings by any of these planes and a 1050-foot strip suitable for minimum operations.

Table 2. Characteristics of certain aircraft (DO-27, DHC-3, DHC-4).

Characteristic			Dornier DO-27	Otter DHC-3	Caribou DHC-4
Gross weight			4070 lb	8000 lb	26,000 lb
Takeoff run on hard surface (with full load and zero wind)			610 ft	655 ft	530 ft (flaps 30°) 990 ft (flaps 15°)
Takeoff run on soft surface (with full load and zero wind)			653 ft	701 ft	567 ft (flaps 30°)
Landing roll			300 ft	490 ft	535 ft (concrete) 655 ft (airline standards)
Wing span			40 ft	58 ft	96 ft
Climb grade			est. over 10%	12%	19%
Wheel track			est. ca. 10 ft	11 ft 2 in	23.1 ft
Clearance			est. ca. 12 in	11.5 in (prop)	21.9 in (prop)
Landing gear configuration (nose to left)			- - -	- - -	= = =
Wheel load			2035 lb	4000 lb	13,000 lb (gear) 6500 lb (wheel)
Footprint pressure			est. 30 psi	est. 30 psi	38 psi
Tire pressure			est. 30 psi	est. 30 psi	39 psi
Approximate landing strip requirements based on an assumed footprint pressure of 40 psi, for safety 1/	100 coverages	Cone index	110	115	140
		Equivalent CBR	3.8	4.0	4.9
	50 coverages	Cone index	100	105	125
		Equivalent CBR	3.4	3.6	4.4
	20 coverages	Cone index	85	90	110
		Equivalent CBR	2.8	3.1	3.8
	5 coverages	Cone index	70	75	90
		Equivalent CBR	2.3	2.5	3.0
	1 coverage	Cone index	50	60	70
		Equivalent CBR	1.7	1.8	2.3
	Minimum runway length to meet emergency or pioneer airfield standards		718 ft	771 ft	624 ft (flaps 30°)
	Minimum runway length to meet minimum-operational airfield standards		980 ft	1052 ft	851 ft (flaps 30°)

1/ Based on graphs in Molineux, C. E., 1955, Remote determination of soil trafficability by the aerial penetrometer: Air Force Cambridge Research Center, Air Force Surveys in Geophysics, Report No. 77, 46 p.

The East Greenland field party included the following members:

Dr. Joseph H. Hartshorn, Geologist, U. S. Geological Survey; Scientific Leader of East Greenland Party
George E. Stoertz, Geologist, U. S. Geological Survey; Deputy Scientific Leader of East Greenland Party
Allan N. Kover, Geologist, U. S. Geological Survey
Dr. Stanley N. Davis, Geologist, Arctic Institute of North America
Lowell R. Satin, Geologist, Arctic Institute of North America
Ole Skaerbo, Civil Engineer, Ministry of Greenland; Chief of Surveying Party

The itinerary in the Scoresbysund area was:

15 August 1959	- USS ATKA anchored in Rosenvinge Bugt; reconnaissance of Scoresbysund area by ATKA-based Navy helicopters
16 August	- Field party arrived Kap Tobin Site via helicopter; established campsite at Kap Tobin Site
16-17 August	- Field work at Kap Tobin Site
17 August	- Field party returned to USS ATKA via helicopter
18 August	- Field work at Kap Tobin Site and Hvalrosbugt Site; ATKA departed for Syd Kap at 1800 hrs.
19-20 August	- Reconnaissance of sites in Scoresby Sund-Hall Bredning area by ATKA-based Navy helicopters; results reported in another section of the report (Part II)
21 August	- USS ATKA arrived Rosenvinge Bugt; field work at Jaettedal Site
22 August	- ATKA departed for Mesters Vig

Summary of Scientific and Engineering Work Near Scoresbysund

Significant accomplishments and investigations included:

1. Location of a 1550-foot x 100-foot landing strip for light planes at the Jaettedal Site, located about four miles northwest of Scoresbysund. This strip was tested by one landing by a Dornier (DO-27). The site is considered suitable for emergency use by aircraft with takeoff ground runs up to 1300 feet; it meets minimum operational standards for aircraft with takeoff ground runs up to 950 feet (including the Dornier, Caribou, and Otter, Table 2).

2. Location of a 710-foot x 100-foot strip at the Kap Tobin Site, located about four miles south of Scoresbysund. This site is considered to be the best location for construction of a short landing strip between Scoresbysund and Kap Tobin.

3. Detailed topographic survey of the Jaettedal Site and the Kap Tobin Site by T-2 theodolite. Surveyed areas are approximately 2400 feet x 600 feet (Jaettedal Site) and 1500 feet square (Kap Tobin Site).

4. Detailed measurement of soil shearing strength of the Jaettedal Site and the Kap Tobin Site, and hasty shearing strength tests along the centerline of the two landing strips presently in use at the Hvalrosbugt Site, and at several other locations in the area. Shearing strength of the soil was recorded about 5250 times in 825 penetrations at 275 locations in the Scoresbysund area.

5. Investigation of soil and subsurface conditions on the Jaettedal Site and the Kap Tobin Site, including excavation of soil test pits, collection of soil samples for identification and laboratory determination of engineering characteristics, ground temperatures, and partial measurement of moisture content in the active zone.

6. Completion of a surficial geologic map of the area around the Kap Tobin Site.

7. Investigation of water supply in the Kap Tobin area, including collection of water samples for chemical analysis.

GENERAL FEATURES OF THE SCORESBYSUND AREA

Location

The village of Scoresbysund is located on the south coast of Liverpool Land, East Greenland, on the north shore of Scoresby Sund near its mouth. The three sites described below are located along the north and east sides of Rosenvinge Bugt. The best two sites for landing light aircraft are on the north side of Hvalrosbugt, the small bay located west of Scoresbysund. Scoresbysund is located approximately at latitude 70°29'N, longitude 21°59'W.

Accessibility

Scoresbysund lies near the air route between Mesters Vig and Keflavik, Iceland, being approximately 450 statute miles (391 nautical miles) from Keflavik and about 127 statute miles (110 nautical miles) from Mesters Vig. The area is well-situated to be an emergency alternate for Mesters Vig, as it is closer to that station than any other established airfield.

The area is normally accessible by ships from July to September, although there are great variations in ice conditions from year to year. The waters around Kap Tobin and Scoresbysund are not particularly suitable for seaplane landings. Coastal pack ice usually drifts southward beyond the mouth of Scoresby Sund and is often driven into sheltered areas and bays such as Rosenvinge Bugt.

Meteorological Aspects

Weather records are available from three stations in the Scoresbysund area, including: complete data for at least a 10-year period from Scoresbysund (station elevation 56 feet); temperature, precipitation, and wind records for a 2- to 4-year period from Hvalrosbugt, located about one mile north of Scoresbysund at an elevation of 29 feet; and records of cloudiness and fog for a 2-year period from Kap Tobin, located about 5 miles south of Scoresbysund at an elevation of 138 feet. The Scoresbysund and Hvalrosbugt data would be most applicable to the Hvalrosbugt and Jaettedal landing sites while the Scoresbysund and Kap Tobin data would be applicable to the Kap Tobin Site, which is midway between those stations. The following general summary of weather is based on the available records from all three stations; statistical data are summarized in Tables 3 and 4.

Mean monthly temperatures at Scoresbysund are below freezing 8 months of the year, from October until May, and mean daily minimum temperatures are below freezing for 10 months, from September until June. Proximity of the area to large water bodies results in cool summers and relatively mild winters for this high latitude. Temperatures both below freezing and above freezing have been recorded during every month of the year and no month has a mean temperature below 0°F. As at Myggbukta (described in Part IV) it would be expected that the ground would freeze and thaw very slowly and would not be frozen deeply enough to support heavy aircraft until mid-November, but by that time snow cover would be sufficient to permit ski-landings in most flat areas.

Annual precipitation is higher than in areas farther north, averaging about 15 inches, distributed fairly uniformly throughout the year. Precipitation of 0.004 inch or more was recorded on only 18 percent of the days throughout the year at Scoresbysund. Snow depths are very great in this area, averaging 2 feet deep or more during the 6-month period from December to May, and averaging 40 inches deep during the month of greatest depth (April). At Hvalrosbugt the snow was deeper

Table 3. Summary of meteorological data for Scoresbysund, East Greenland.

Month	TEMPERATURE					PRECIPITATION				WIND				CLOUDINESS			FOG
	Abs. max. °F	Mean daily max. °F	Mean °F	Mean daily min. °F	Abs. min. °F	Mean days with prec. 1/	Mean month. prec. (in.)	Mean days with snow 2/	Mean snow depth (in.)	Ave. spec. wind speed (mph)	Maximum wind speed: Direc.	Maximum wind speed: mph	Mean days with gales	Mean month. cloud. (%)	Mean clear days 3/	Mean cloudy days 4/	Mean days with fog
JAN	48	12	5	-3	-37	9	1.9	8	24	5	N (incl.	75 DEC)	10	56	7	11	4
FEB	41	12	4	-4	-38	8	1.4	8	25	5			6	59	6	11	6
MAR	47	14	5	-4	-42	7	0.9	7	28	5			9	53	8	10	6
APR	45	22	14	6	-30	4	1.4	4	40	4	N	70	10	52	9	8	8
MAY	49	33	27	20	0	. . .	0.4	0	39	3			6	62	6	12	15
JUN	60	43	37	31	22	4	0.8	1	8	3			4	56	6	10	14
JUL	63	49	42	36	28	5	1.5	0	0	3	N	40	6	55	6	9	11
AUG	54	45	39	33	26	1	0.7	0	0	3			3	58	5	7	8
SEP	62	39	34	29	10	7	1.9	5	0	3			8	55	6	10	9
OCT	47	25	20	15	-13	6	1.0	5	5	4	N	65	10	56	7	10	5
NOV	52	19	13	6	-27	5	1.1	5	11	4			8	59	6	11	4
DEC	40	15	8	1	-38	6	2.0	7	22	4			6	60	7	12	6
Annual	63	27	21	14	-42	ca 99	15.0	50	. . .	4	N	75	86	57	79	121	96
Yrs. Rec.	10	11	10	10	10	9	5	4	. . .	12	2		2	11	9	9	11

1/ 0.004 inch or more
2/ More than a trace
3/ Cloud cover equal to or less than 2/10
4/ Cloud cover greater than or equal to 8/10

Table 4. Summary of meteorological data for Hvalrosbugt and Kap Tobin (near Scoresbysund), East Greenland.

Month	TEMPERATURE at Hvalrosbugt					PRECIPITATION at Hvalrosbugt				WIND at Hvalrosbugt			CLOUDINESS at Kap Tobin			FOG Kap Tobin
	Abs. max. °F	Mean daily max. °F	Mean °F	Mean daily min. °F	Abs. min. °F	Mean days with prec. 1/	Mean month. prec. (in.)	Mean days with snow 2/	Mean days with snow depth over 6 in.	Maximum wind speed Direc.	Maximum wind speed mph	Mean days with gales	Mean month. cloud. (%)	Mean clear days 3/	Mean cloudy days 4/	Mean days with fog
JAN	36	27	18	9	-29	14	1.9	15	31	NNE (incl.	55 DEC)	6	64	10	18	2
FEB	45	13	3	-6	-25	6	0.5	11	28			4	57	11	13	2
MAR	33	10	0	-10	-29	6	0.4	10	31			3	57	11	14	2
APR	33	19	10	0	-21	8	1.0	12	30	NW	32	2	54	12	13	2
MAY	55	35	27	20	2	4	0.6	8	31			2	66	9	18	6
JUN	67	42	35	29	16	5	0.8	4	14			2	78	6	21	8
JUL	63	49	41	34	30	9	1.8	1	0	NE	40	1	68	7	17	16
AUG	55	47	40	33	26	8	3.3	1	0			1	59	10	15	11
SEP	53	39	34	28	18	8	1.3	9	0			4	60	10	15	4
OCT	53	32	24	17	0	6	1.3	13	10	NE	75	4	78	6	22	1
NOV	51	19	11	3	-21	6	1.8	10	22			4	54	12	14	2
DEC	35	18	10	3	-27	13	1.1	17	23			6	67	9	18	1
Annual	67	29	21	13	-29	93	15.8	111	220	NE	75	39	64	113	198	57
Yrs. Rec.	2	2	2	2	2	3	3	4	3	4		4	3	3	3	3

1/ More than a trace. 2/ Equal to or greater than a trace. 3/ Cloud cover 3/10. 4/ Cloud cover 8/10.

than 6 inches on 60 percent of all days during a 3-year period of record and 80 percent of all days during the 8-month period from October to June.

Wind speeds are usually not high, averaging only 3 to 5 mph during every month. The strongest winds are from a northerly direction, nearly due north at Scoresbysund and northeast at Hvalrosbugt. Maximum wind speeds of 75 mph have been recorded at both stations.

Mean cloudiness averages 57 percent at Scoresbysund and is fairly uniform throughout the year. During any month in the year a mean cloudiness from 50 to 60 percent can be expected at that station. There are many foggy days in this area, especially during the 5-month period from May to September. During this period fog was reported on more than 40 percent of all days during an 11-year period of record at Scoresbysund.

HVALROSBUGT SITE: SITE PRESENTLY IN USE NEAR SCORESBYSUND

Location

The landing area is about one mile north of Scoresbysund, on the east side of Hvalrosbugt, immediately south of the abandoned Hvalrosbugt weather station. Location is approximately latitude 70°30'N, longitude 21°59'W (Photograph 8).

Accessibility

It is easily accessible by boat, but inaccessible by vehicle in summer. It is easily accessible from Scoresbysund by a path along the water's edge. Overland distance to Scoresbysund is not over one mile. Distance to Kap Tobin is about 6 miles by water or 8 miles by land, but the overland route is impassable by vehicles. When ice conditions in Rosenvinge Bugt are unfavorable for either boat or overice travel, the site is nearly inaccessible from Kap Tobin.

Approaches

Air approaches from the south and southwest are over Hvalrosbugt and are unrestricted. Approach from the north is unrestricted over the valley of Maageelv. Approach from the northeast may be somewhat restricted by the steep hillside east of Maageelv.

Photograph 8. HUP-2 helicopter at Hvalrosbugt Site. HUP-2 used for helicopter operations taking off from unprepared landing strip on outwash plain at Hvalrosbugt, one mile north of the village of Scoresbysund. Date: 18 August 1959.

Dimensions and Orientation

There are two landing strips, one oriented in a northeast-southwest direction and the other in a north-south direction. The former is about 850 feet x 50 feet; the latter is about 900 feet x 50 feet. The NE-SW orientation is said to be the most frequently used, at least in summer. The N-S orientation is marked by gasoline drums and may be more frequently used when the ground is snow-covered, although this is uncertain. The landing strips probably could not be extended appreciably in any direction because of the presence of erosional terrace scarps, but width could be increased to 100 feet.

Topography and Landforms

The site is on a gently sloping terrace of outwash gravel and sand a few feet above the level of Maageelv, a stream that flows southwestward from two glaciers in southern Liverpool Land. The southern part of the landing area ends at the sand beaches along the shore of Hvalrosbugt, and the northern part terminates against a bedrock-cored till hill with numerous large boulders on the surface. The NE-SW landing strip slopes upward toward the northeast. The northeastern end slopes quite steeply and the southwestern end has two or three gentle rolls. The N-S landing strip appears fairly level and flat.

Soil Characteristics

The shearing strength of the natural soil surface on the NE-SW landing strip is very high (Fig. 2), as evidenced by shearing strength tests made on 18 August with a WES cone penetrometer at intervals of 100 feet along the centerline. At a depth of 3 inches the cone index averaged 372, equivalent to a CBR of about 14. At no point was the cone index found to be less than 283 [2/], equivalent to a CBR of over 10, which would be adequate to support numerous landings and takeoffs by planes as heavy as a C-124 and would be more than adequate for any planes that might conceivably be used on a landing strip of that length (850 feet). A cone index of 420, equivalent to a CBR of at least 15 (the maximum value that could be recorded with the WES cone penetrometer) was recorded at an average depth of only 3 1/2 inches. The shearing strength of the natural soil surface is considered sufficient to support at least 100 coverages [3/] by a Caribou (DHC-4), Otter (DHC-3), or Dornier

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2/ Cone index values were measured to the nearest fives or tens. Three readings were made at each test station and averaged to obtain values that are generally considered accurate to ±3. All cone index values in this report are averages of at least 3 readings, the accuracy increasing with the number of values averaged.

3/ One coverage is equivalent to two landings and two takeoffs.

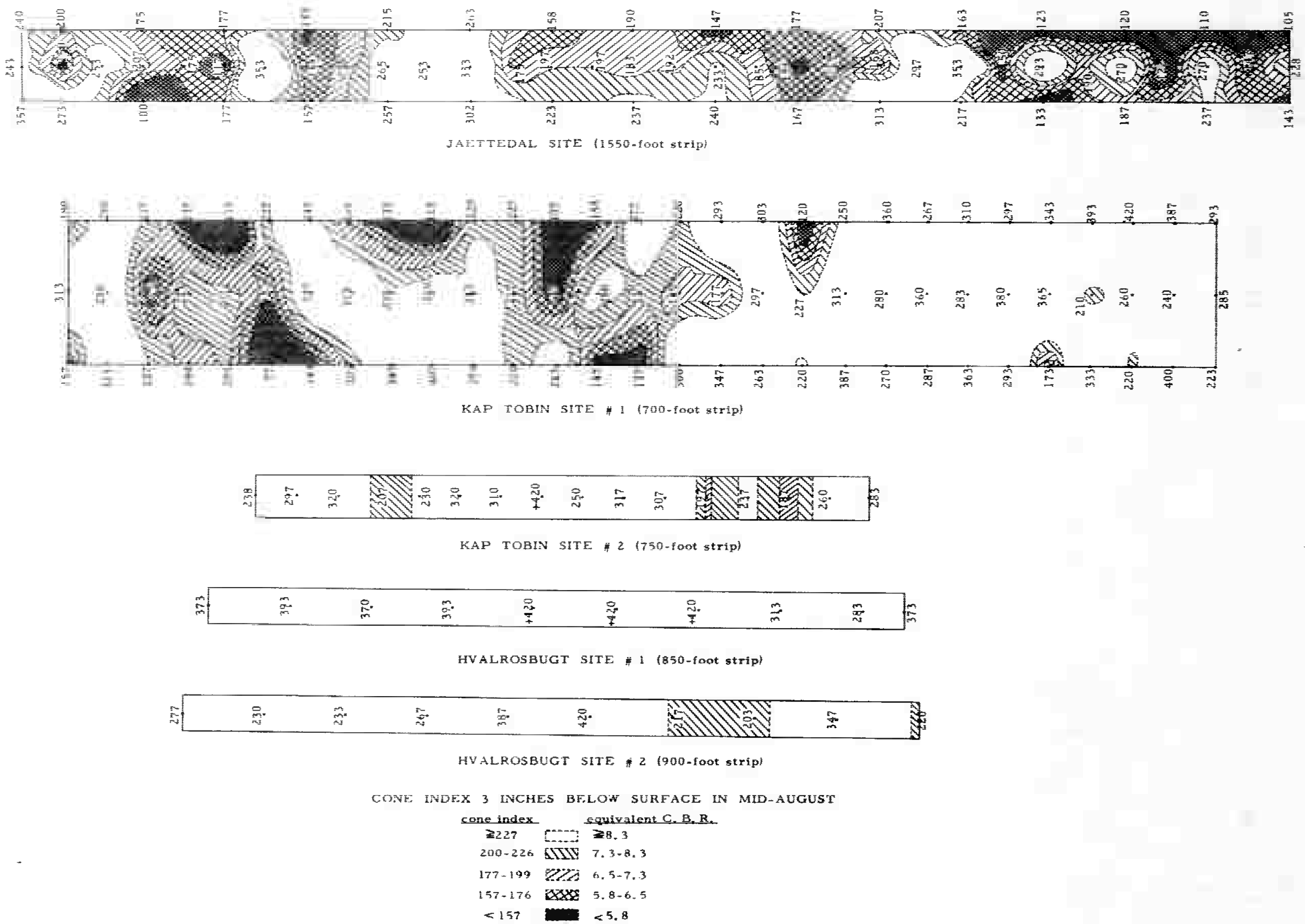


Figure 2. Soil strength of landing strips near Scoresbysund.

(DO-27). The surface of the strip has apparently been compacted and considerably strengthened by traffic. This is an indication of the potential strength after traffic of many similar strips in East Greenland, including the Jaettedal Site and more than one possible site in the Storelv area.

The shearing strength of the natural soil surface on the N-S landing strip is somewhat lower (Fig. 2), but is also more than adequate for light aircraft. At a depth of 3 inches the cone index averaged 280, equivalent to a CBR of about 10. A cone index of 420, equivalent to a CBR of at least 15, was recorded at an average depth of 4 1/2 inches. The weakest area is located near the north end of the strip, in the area from about 150 to 300 feet from the end of the strip. In this area the shearing strength at a depth of 3 inches is equivalent to a CBR of about 7. However the natural surface is considered sufficiently strong to support at least 100 coverages by a Caribou (DHC-4), Otter (DHC-3), or Dornier (DO-27).

Construction Materials

Sand and gravel can be obtained from the river flood plain immediately west of the site, from the edges of the terrace on which the site is located, or from similar terraces on the west side of the river. Sand can be obtained south of the site from a barrier beach bordering Hvalrosbugt.

Other Possible Landing Sites in the Vicinity

A possible site for a 1000-foot x 100-foot landing strip is located about one-half mile north of the present site on a turf-covered gravel terrace 4 to 5 feet above the flood plain of Maageelv. The soil characteristics and shearing strength are similar to the NE-SW orientation at the present site. It is nearly level and free of microrelief features with the exception of a few shallow swales near the north end. These are as much as 6 inches lower than the predominant level of the possible landing strip, but run nearly parallel to it so they would not impede aircraft landings or takeoffs. The orientation of the site is NE-SW, roughly parallel to Maageelv. Approaches are similar to the NE-SW orientation of the present site. It is probable that the landing area could be extended to 1050 feet and that short overrun areas could be provided by removing boulders from the north and south ends of the area. Most of these boulders appear to be lying on the surface, not imbedded in it.

Conclusions

A comparison of this site with other possible sites in the area is shown in Table 5. The site presently in use by light aircraft near

Table 5. Comparison of alternative sites for short landing strips near the village of Scoresbysund.

Present condition of landing sites		Hvalrosbugt Site (site presently in use) Runway # 1	Hvalrosbugt Site (site presently in use) Runway # 2	Jaettedal Site	Kap Tobin Site
Location (approximately)		lat. 70°30'N, long. 21°59'W		lat. 70°31'N long. 22°05'W	lat. 70°26'N long. 21°58'W
Orientation (approximately)		NE - SW	N - S	NE - SW	N - S
ACCESS	Distance from Kap Tobin	8 miles		11 miles	2 miles
	Accessibility from Kap Tobin (summer)	Poor		Very poor	Good
	Distance from Scoresby-sund (overland)	1 mile		4 miles	5 miles
	Accessibility from Scoresbysund in summer	Fair		Poor	Poor
TOPOGRAPHY	Runway length	850 feet	900 feet	1550 feet	700 ft. (after construction)
	Runway width (possible)	100 feet	100 feet	100 feet	100 ft. (after construction)
	Longitudinal slope	est. 2%	est. 1%	1.1%	0.3%
	Average slope of ground	est. 2%	est. 2%	1.2%	1.0%
SOIL STRENGTH	Average cone index at 3-inch depth	372	280	205	251
	Equivalent CBR at 3-inch depth	14	10	7	9
	Average depth of 420 cone index reading (equivalent CBR at least 15)	3 1/2 in	4 1/2 in.	6 in.	4 1/2 in.
	Minimum cone index at 3-inch depth at 100-foot intervals on centerline	283	203	117	137
	Equivalent CBR at 3-inch depth	10	7	4	5
	Absolute minimum cone index at 3-inch depth recorded in runway area	Inadequate data are available because readings were only made near the centerline; these minimum values are shown above		100	77
	Equivalent CBR at 3-inch depth			3 1/2	2 1/2
EVALUATION	Estimated minimum no. of coverages by Dornier which soil surface will safely support	100	100	50	5 (after construction)
	Estimated minimum no. of coverages by Otter which soil surface will safely support	100	100	20	5 (after construction)
	Estimated minimum no. of coverages by Caribou which soil surface will safely support	100	100	5	1 (after construction)

Scoresbysund appears to satisfy the requirements of an emergency or pioneer airfield for such planes as the Dornier (DO-27), Otter (DHC-3), and Caribou (DHC-4), assuming takeoff by Caribou would be with flaps at 30°. The site does not meet the standards of a minimum-operational airfield for any of these planes, principally because overruns are not available at the ends of the runways and neither orientation is quite long enough for the Otter or the Dornier (requiring about 1050 feet and 1000 feet, respectively, to meet minimum-operational standards).

Because of its relatively good accessibility, firm surface, and favorable orientations, the site appears to be the most suitable in the Scoresbysund area for emergency use by light aircraft; however safety factors are very small.

Recommendations

The Jaettedal Site, described in a following section, is recommended to supplement the Hvalrosbugt Site if Danish authorities desire to: (1) increase some safety factors such as runway length; (2) use larger aircraft than those presently in use at Scoresbysund; (3) increase significantly the number of landings and takeoffs in the area; or (4) have an alternative NE-SW landing strip available for use during repairs or improvement of the present site. In addition it is recommended that the area immediately north of the present landing site be investigated for another alternative NE-SW landing strip that might afford slightly greater safety factors with little loss of accessibility; this area was not investigated in detail in 1959.

JAETTEDAL SITE: FOUR MILES NORTHWEST OF SCORESBYSUND

Location

The site is four miles northwest of Scoresbysund on the east side of the river that flows through the valley known as Jaettedal, about one mile upstream from the mouth of the river. It is approximately at latitude 70°31'N, longitude 22°05'W.

Accessibility

The site is inaccessible by wheeled vehicles in summer since streams and steep slopes lie between the site and Scoresbysund. The site could be reached by a 3-mile boat trip plus one-mile overland walk. Easily accessible from Scoresbysund in winter when Rosenvinge Bugt is frozen.

Approaches

Air approach from the southwest is over Hvalrosbugt and is unrestricted. A low hill lies immediately east of the flightway near the southwest end of the strip. Approach from the northeast is via Jaettedal and is slightly restricted by the low hills that border the valley.

Dimensions and Orientation

The runway is 1550 feet x 100 feet, oriented approximately N35° E. Emergency overrun areas about 200 feet long are situated at opposite ends of the strip. The entire terrace on which the runway is situated is nearly 3000 feet long, but the best landing area occupies only the southern one-half. To the north and east of the runway the smooth surface of the terrace disintegrates into the cobbly surface of an abandoned stream channel. Extension to the south or west is prevented by active stream channels bordered by scarps 6 to 10 feet high.

Topography and Landforms

The site is on a gently sloping terrace of outwash gravel and sand about 6 to 10 feet above the river flood plain that borders it to the northwest. The terrace is a remnant of a formerly more extensive outwash plain that occupied the lower Jaettedal from the foot of the mountains to the sea. As the glaciers retreated, this plain was dissected and remnants left as terraces from 3 to 10 feet above the present glacial stream. The terrace slopes downward toward the south at an average of 1.2 percent, giving the runway an average longitudinal grade of 1.1 percent. The terrace is crossed by a few shallow swales that are traces of abandoned stream channels (Photograph 9). They are a few feet to 50 feet wide, and a few inches to 20 inches deep. Most of these are nearly parallel to the runway and are so wide in relation to their depth that they would not impede aircraft landings and takeoffs. The location of these features is shown on the topographic map (Fig. 3).

Soil Characteristics

The strength of the natural soil surface as measured by cone penetrometer is only moderate (Fig. 2), but one test landing has shown that the surface affords sufficient strength to safely support a Dornier (DO-27) without appreciable rutting. Soil strength tests were made on 21 August with a WES cone penetrometer at intervals of 50 feet along the centerline and 100 feet along the edges. They showed that at a depth of 3 inches the cone index averaged 205, equivalent to a CBR of about 7. At the softest point along the centerline the cone index at a 3-inch depth was found to be 117 (equivalent to a CBR of 4). The maximum measurable cone index reading of 420 (equivalent to CBR of

Photograph 9. Ground and aerial views of the Jaettedal airstrip (Site #2). Aerial view is southwest toward Rosenvinge Bugt, showing location of centerline. Ground view is along the centerline from near the south end. The range poles mark the centerline; the flags mark the edges. The site is smooth and free of microrelief features with the exception of shallow swales, such as the one shown in the foreground, about 6 inches lower than the predominant level of the landing strip. However these are nearly parallel to the runway and would not impede landings and takeoffs. View northeast. Date: 21 August 1959.

at least 15) was obtained at an average depth of 6 inches. The absolute minimum cone index recorded at a 3-inch depth within the runway area was a value of 100, equivalent to a CBR of 3 1/2. Since the cone penetrometer cannot measure the strength of the vegetation, these data do not adequately reflect the true strength of the natural surface. From the performance of the Dornier during the test landing and from soil strength tests it is estimated that the surface will safely support at least 50 coverages by the Dornier, at least 20 coverages by an Otter (DHC-3), or at least 5 coverages by a Caribou (DHC-4). Since the soil conditions are nearly identical to those on the Hvalrosbugt Site, presently in use near Scoresbysund, it is probable that traffic by light aircraft will strengthen the surface of the Jaettedal Site somewhat (Table 6).

Construction Materials

Sand and gravel can be obtained from the river flood plain immediately west of the site or from the edge of the terrace on which the site is located (Photograph 10). With moderate construction effort the site could probably be extended several hundred feet toward the northeast.

Conclusions

The site is the longest natural landing site in the Scoresbysund area, but is slightly less accessible to Scoresbysund and Kap Tobin than the Hvalrosbugt Site presently in use near Scoresbysund. For the present scale of aircraft operations in support of the Danish stations the Jaettedal Site, in spite of its greater length, appears slightly less suitable than the Hvalrosbugt Site for the following reasons: (1) it is slightly less accessible; (2) the runway orientation is restricted to a northeast-southwest direction, while the present site affords several possible orientations; and (3) the soil strength is slightly lower than on the present site, although a test landing showed it to be adequate for use by light aircraft.

Recommendations

The Jaettedal Site is recommended for use in support of Scoresbysund and Kap Tobin if Danish authorities desire to: (1) increase some safety factors such as runway length; (2) use aircraft with longer ground runs than those presently in use at Scoresbysund; (3) increase significantly the number of landings and takeoffs in the area; or (4) have an alternative NE-SW strip available for use during repairs or improvement of the present site at Hvalrosbugt.

Photograph 10. Terrace of outwash gravel and sand on which the Jaettedal airstrip is situated, about 6 feet above the flood plain of the Jaette. Abundant sand and gravel can be obtained from the flood plain or from the edge of the terrace. A test landing by a Dornier (DO-27) demonstrated that the natural surface will safely support that aircraft and will probably support landings by an Otter (DHC-3) or a Caribou (DHC-4). View northeast. Date: 21 August 1959.

KAP TOBIN SITE: FOUR MILES SOUTH OF SCORESBYSUND

Location

The site is about four miles south of Scoresbysund on the east shore of Rosenvinge Bugt. It is situated midway between Kap Tobin and Scoresbysund, approximately at latitude 70° 26'N, longitude 21° 58'W.

Accessibility

The site is easily accessible by road from Kap Tobin (2 miles to the south); the present road from Kap Tobin crosses the immediate area of the site. Scoresbysund lies 5 miles to the north, but the overland route is impassable to vehicles. The site is accessible by boat

Table 6. Soil sections in the Scoresbysund area, East Greenland

A. Soil section at Kap Tobin Site

Date: 16 August 1959
Location: Test pit 120 feet north of south end of airstrip, 20 feet east of centerline.

Depth	Description	Depth	Soil temp.	Moisture content
0- 2 in.	Pebble-rubble surface composed of angular fragments of gneiss mostly less than 1 inch in size, larger fragments mostly 1-4 inches, scattered large cobbles and boulders from 4 inches to several feet across.	Surface	43°F	2.7%
2-24 in.	Sand and angular gravel similar to above; size and proportion of gravel fraction increases downward.	6 in. 12 in. 18 in.	42°F 40°F 39°F	3.2% 3.1% 2.9%
24 in.	Broken, weathered bedrock (Precambrian gneiss)	24 in.	38°F	...

B. Soil section on raised beach terrace near Kap Tobin Site

Date: 16 August 1959
Location: Test pit 600 feet southeast of southeast corner of airstrip.

Depth	Description	Depth	Soil temp.
0- 2 in.	Vegetation and organic matter	Surface 2 in.	42°F (air) 41°F
2-34 in.	Sand and gravel with size and proportion of gravel fraction increasing downward. Surface is sandy, small to medium pebble gravel, with some large boulders. Material is very poorly stratified, the stratification becoming more noticeable as the material dries out.	8 in. 14 in. 20 in. 26 in. 32 in.	40°F 39.5°F 39°F 38°F 37°F

C. Soil section at Jaettedal Site

Date: 21 August 1959
Location: Test pit near south end of Jaettedal airstrip.

Depth	Description	Depth	Soil temp.
0- 2 in.	Vegetation and organic matter	Surface 2 in.	47°F (air) 43°F
2-24 in.	Coarse sand and gravel with numerous small cobbles; alternating layers of poorly graded gravel and poorly graded sand.	6 in. 12 in. 18 in. 24 in.	39.5°F 38°F 37°F 36°F

from Scoresbysund, being 3 miles distant by water; the site is 750 feet east of the shore of Rosenvinge Bugt.

Approaches

Air approaches from either the north or south are unrestricted. From the south, approach would be over Scoresby Sund and Kap Tobin. From the north, approach would be over Amdrup Havn and the village of Scoresbysund. Low hills lie to the east of the site and the terrain gradually slopes upward toward the northeast at an average of about 10 percent to a height of 925 feet within a distance of 2 miles.

Dimensions and Orientation

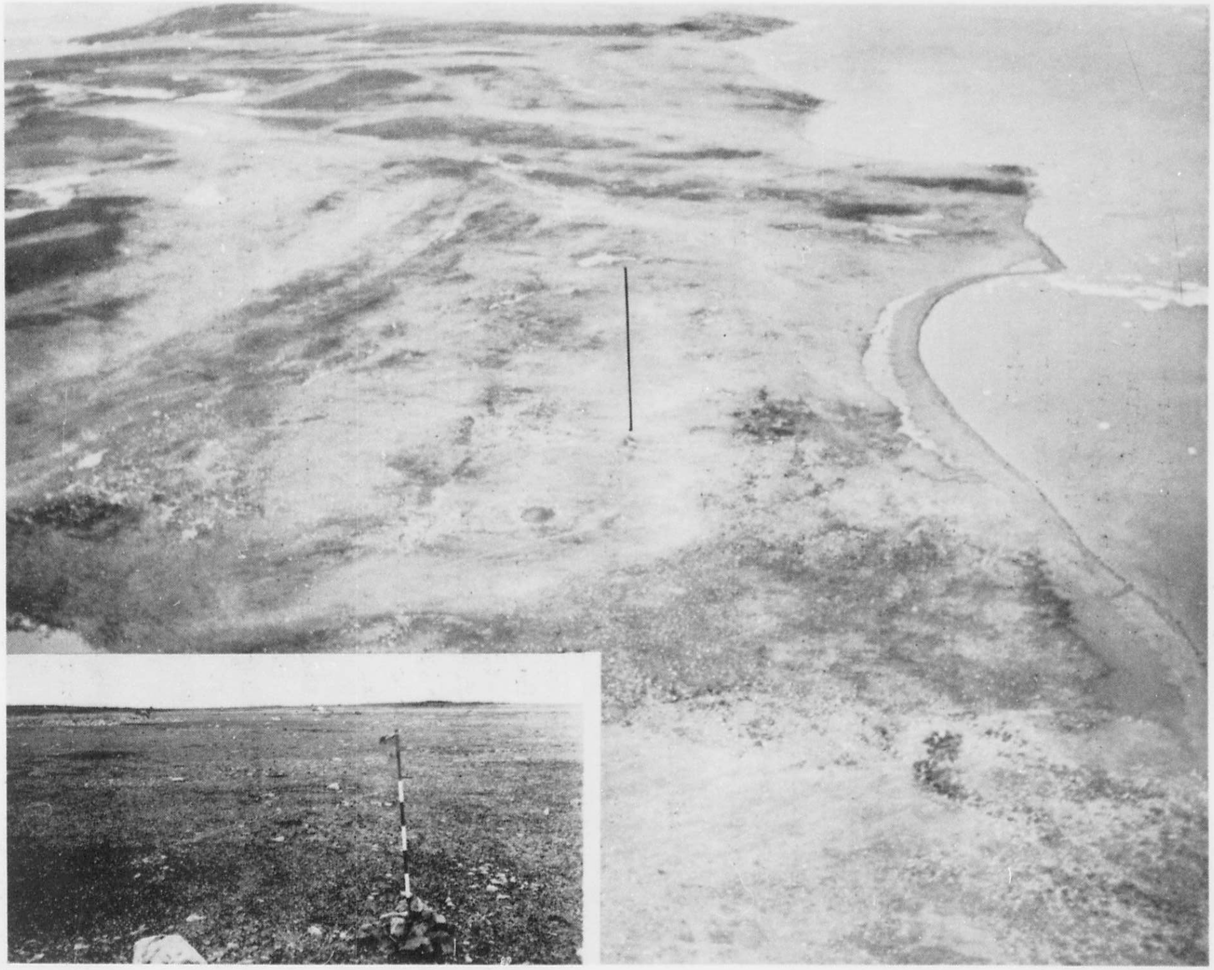
At present the site is unsuitable for aircraft landings. The area requiring the least construction effort has been marked on the ground by cairns spaced 50 feet apart along the edges. This area is 710 feet x 100 feet, oriented N26° E. Moderate construction effort, involving some blasting, stripping, and filling, would be required to extend the strip either north or south along the present centerline (Photograph 11). With moderate construction effort a landing strip at least 2000 feet long could probably be built in this area.

Topography and Landforms

The site is on a coastal lowland that slopes gently upward from sea level at the shore of Rosenvinge Bugt to an elevation of about 50 feet at the base of the low hills to the east. Average slope of the lowland is about 3 percent, but in the immediate vicinity of the site the slope of the ground averages only 1 percent (Fig. 4). The smooth surface of the site area is broken only by small knobs of shattered bedrock that rise a few feet above the surface of the plain.

West of the site area, along the shore of Rosenvinge Bugt, is a modern beach ridge or ice-shove ridge 5 to 10 feet high, composed of angular to subangular cobbles and pebbles. East of the site area is a series of raised beach ridges or marine terraces at elevations from 36 to 50 feet above sea level, composed largely of pebble gravel and sand.

The bedrock, thinly mantled by surficial debris, is of two main types: (1) a biotite-quartz-feldspar schist, with some amphibolitic schist; and (2) a granite gneiss. Both rocks tend to split into angular slabs under the impact of weathering.



Photograph 11. Ground and aerial views of the Kap Tobin Site (#1). Aerial view is southward toward Kap Tobin (center background), showing location of centerline. Ground view is along the centerline from the north end. The range pole marks the centerline of the strip. If it is essential to have a short landing strip near Kap Tobin, this is considered to be the best available site for constructing a 710-foot x 100-foot strip with a minimum of effort. The site is at present unsuitable for aircraft landings because of scattered large cobbles and boulders. View south. Date: 17 August 1959.

Soil Characteristics

In the immediate site area the surface is either completely free of vegetation or has a thin cover of mosses and lichens, seldom over 1 inch thick. In a few areas of moister or finer-grained soil in the vicinity the vegetation layer is thicker and more continuous. For example the raised beach ridges are covered by a mat of organic matter that averages about 2 inches thick (Table 6B) and forms rounded tussocks that join to form a polygonal pattern 6 to 12 inches across. Similar vegetation characterizes most areas of wet ground in the lowland.

The surface of most of the lowland is a pebble- or cobble-sized rubble composed of angular rock fragments, mostly 1 to 4 inches across. The fragments are mostly of Precambrian gneiss with lesser quantities of schist. In the immediate vicinity of the 710-foot airstrip the surface is a pebble-rubble in which most fragments are less than one inch in size, the larger fragments are 1 to 4 inches in size, and there are scattered cobbles and boulders ranging from 4 inches to several feet across.

Immediately beneath the coarse surface layer, the soil is commonly composed of a mixture of pebbles, cobbles, and sand (Table 6A and 6B). The size and proportion of large rock fragments generally increases with depth, passing into broken weathered bedrock at a shallow depth, estimated to average 2 to 6 feet deep. Outcrops of Precambrian gneiss and schist are exposed at many places immediately east of the site, and at one location a rock outcrop determines its eastern edge.

The strength of the natural soil surface is moderate (Fig. 2) as evidenced by tests made on 16-17 August with a WES cone penetrometer at intervals of 25 feet along the centerline and edges. At a depth of 3 inches the cone index averaged 251, equivalent to a CBR of about 9. At the softest point along the centerline the cone index at a depth of 3 inches was found to be 137 (equivalent to a CBR of 5). The maximum measurable cone index reading of 420 (equivalent to a CBR of at least 15) was obtained at an average depth of 4 1/2 inches. The absolute minimum cone index recorded at a 3-inch depth within the runway area was a value of 77, equivalent to a CBR of 2 1/2.

From these data it appears questionable whether the natural surface is strong enough to safely support landings by planes, even as light as a Dornier (DO-27). However the cone penetrometer tended to overturn angular pebbles near the surface and to penetrate the softer soil between them, resulting in low readings. The cone penetrometer is probably not suitable for measuring the strength of gravelly or rubbly soils, especially where many large or flat fragments are concentrated at or near the surface. From a visual examination of the surface and from its observed behavior under truck traffic and under the wheels of a helicopter it is estimated that the natural surface of the site is safe for at least five coverages by a Dornier (DO-27), after removal of large cobbles and boulders.

Construction Aspects

Scattered boulders and cobbles 6 inches to several feet across would have to be removed from the surface, and the resulting holes filled with gravel and rubble similar to the rest of the surface. Suitable material can be obtained along the road west of the site. The modern beach ridge, which is composed of a matrix of sand with angular to subangular pebbles and cobbles, is a suitable source of aggregate. The inhabitants of Kap Tobin use the beach for this purpose at the present time, and have a small active pit about 1500 feet northwest of the airstrip.

The lowland is topographically suitable for construction of an airstrip at least 2000 feet long. This would require blasting and removal of some very large boulders or small bedrock outcrops, and filling or resurfacing areas of wet ground or cobble-rubble. Extension of the strip to the north would require blasting of a small outcrop of Precambrian gneiss located 35 feet to the north. In addition it would require stripping and resurfacing an area of cobble-rubble located about 80 feet north of the north end. Extension of the strip to the south would require stripping and filling of an area of wet ground located 20 to 100 feet south of the south end. When this is accomplished the strip could be extended an additional 400 feet to the south with little additional effort, but further extension would require stripping and resurfacing the entire area which consists of cobble-rubble (Fig. 5).

Very little fresh water is available at the airstrip. A pond about 800 to 1000 feet in diameter, with a small stream flowing to the ocean, is located less than a mile north of the airstrip; no examination was made of this possible source of water. The inhabitants of Kap Tobin get their water from a pool formed in a weathered-out joint system in bedrock. No likely sources of surface water occur in the vicinity.

Conclusions

The site is at present unsuitable for aircraft landings because of the presence of scattered large cobbles and boulders. Removal of these and filling of holes would require minor construction effort within the 710-foot x 100-foot strip presently delimited by stone cairns. The resulting surface is estimated to be suitable for emergency landings by a Dornier. With moderate construction effort it is estimated that a 2000-foot airstrip could be constructed in the area.

Recommendations

If it is essential to have a short landing strip near Kap Tobin, the Kap Tobin Site is considered to be the best available site for constructing a 710-foot strip with a minimum of effort. However, even after removal of the boulders, this site is considerably inferior to the Hvalrosbugt Site, presently in use near Scoresbysund, and it is recommended that the Kap Tobin Site be used only in emergencies, unless the natural surface is improved.

If it is desired to construct a long runway in the Scoresbysund area the general vicinity of the Kap Tobin Site is considered to be the most promising location. Exact location of the best centerline would require additional investigation and surveying.

CONCLUSIONS REGARDING SITES FOR LANDING STRIPS NEAR SCORESBYSUND

1. The Jaettedal Site is recommended for use in support of Scoresbysund and Kap Tobin if Danish authorities desire to: (1) increase some safety factors such as runway length; (2) use aircraft with longer ground runs than those presently in use at Scoresbysund; (3) increase significantly the number of landings and takeoffs in the area; or (4) have an alternative NE-SW landing strip available for use during repairs of the present site at Hvalrosbugt.

2. The site presently in use by light aircraft at Hvalrosbugt appears to be the most suitable in the Scoresbysund area for the present scale of aircraft operations in support of the Danish stations at Scoresbysund and Kap Tobin. Its only advantages over alternative sites such as the Jaettedal Site are its slightly better accessibility, slightly higher soil strength, and a choice of runway orientations. However safety factors appear to be small.

3. If it is essential to have a short landing strip near Kap Tobin, the Kap Tobin Site, 4 miles south of Scoresbysund, is considered to be the best available site for constructing a 710-foot strip with a minimum of effort. The site is at present unsuitable for aircraft landings because of scattered large cobbles and boulders. However, even after removal of these, the area would be considerably inferior to the present site near Scoresbysund. The general area of the Kap Tobin Site is also considered to be the most promising location for a long runway

in the Scoresbysund area, but further investigation would be necessary to locate the centerline.

4. A study of aerial photographs of the Scoresbysund area in 1957 failed to disclose any potential landing sites at least 5000 feet long. During subsequent field work and low altitude aerial reconnaissance by helicopter in 1959 a field party of five geologists and one civil engineer failed to locate any sites suitable for long landing strips in this area, corroborating the previous conclusions based on photo interpretation.

PART IV. INVESTIGATION OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN THE STORELV AREA

by

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PART IV. INVESTIGATION OF ICE-FREE SITES FOR AIRCRAFT LANDINGS IN THE STORELV AREA, EAST GREENLAND

SUMMARY

In September 1959 a field party of five geologists and one civil engineer located and surveyed a potential 11,500-foot aircraft landing site on a gravel terrace near Storelv, north of Kejser Franz Joseph Fjord, East Greenland. The operation was staged from MSTS icebreaker USS ATKA, and from Mesters Vig, Greenland. It was supported by U. S. Navy helicopters and by a Dornier (DO-27) operated by the Nordisk Mineselskab A/S (Northern Mining Company), Mesters Vig. On the basis of the engineering studies and tests conducted in 1959, it is considered that at least 10,000 feet of the airstrip are well-suited for hasty construction of an operational airfield. The landing area is 106 miles north of Mesters Vig, directly on the air routes between Mesters Vig and Nord and between Keflavik and Nord. The area is well-situated as an emergency alternate for Mesters Vig. On the basis of further studies conducted in 1960 it is concluded that no unprepared surfaces in the area are safe for operations by aircraft of the C-130 type, although the possibility of emergency landings is noted (see a later GRD report, in preparation).

INTRODUCTION

The Air Force Cambridge Research Center is investigating ice-free land areas of North and East Greenland to locate emergency airstrips requiring a minimum of construction effort. There is a need for emergency landing areas to supplement existing airfields at Nord, Mesters Vig, and elsewhere because of the increasing use of northern airways and the abrupt and severe changes in weather common in this area.

In addition to the emergency airstrip described in this report, several other such sites have been located and tested in northern and eastern Greenland, all requiring very little preparation for aircraft landings. Successful test landings by a C-124 and C-130 on unprepared soil surfaces at Brønlund Fjord, Polaris Promontory, and Centrum Sø have demonstrated that even in the inhospitable terrain of northernmost Greenland it is possible to find ice-free natural landing areas capable of supporting the heaviest cargo planes.

Previous Work

Photo interpretation by the U. S. Geological survey for Air Force Cambridge Research Center during 1957 showed that the Storelv area was one of the most promising potential airfield sites in East Greenland. Dr. Thor N. V. Karlstrom did the photo interpretation of the Storelv area. The principal field investigations in 1959 were along one of the runway sites suggested by Karlstrom. However there was insufficient time to investigate alternative sites in detail during the short field season in 1959.

Operations in 1959

Field investigations in East Greenland in 1959 were undertaken by the Terrestrial Sciences Laboratory, Geophysics Research Directorate, Air Force Cambridge Research Center, with the support of the Military Sea Transport Service. Staging of this operation was from the icebreaker USS ATKA (AGB 3) and from Mesters Vig, Greenland. Field work at Storelv, in the center of the large peninsula north of Kejser Franz Joseph Fjord, was conducted between 30 August and 7 September 1959. The Storelv field party included the following members:

George E. Stoertz, Geologist, U. S. Geological Survey; Party Leader of Storelv Party
Dr. Stanley N. Davis, Geologist, Arctic Institute of North America
Lowell R. Satin, Geologist, Arctic Institute of North America
Ole Skaerbo, Civil Engineer, Ministry of Greenland; Chief of Surveying Party
Dr. Joseph H. Hartshorn and Allan N. Kover, U. S. Geological Survey (members of the party until 1 September)

Further investigations in part incorporated into Table 1 of this report, were made in 1960 by the following:

Donald W. Klick, Capt., USAF; Party Leader of East Greenland Party (1960)
Dr. Joseph H. Hartshorn, U. S. Geological Survey; Scientific Leader of East Greenland Party (1960)
Carlton E. Molineux, Air Force Cambridge Research Center
Ole Skaerbo, Civil Engineer, Ministry of Greenland

The itinerary in the Storelv area was:

30 August 1959 - USS ATKA anchored near MacKenzie Bugt; reconnaissance of Storelv area by ATKA-based Navy helicopter

31 August - Party of nine arrived at Storelv campsite via helicopter

1 September - Five members of party returned to USS ATKA via helicopter; ATKA departed for Mesters Vig

1-7 September - Field work in Storelv area by party of four

7 September - Field party transported by Dornier (DO-27) from Storelv to Mesters Vig

Summary of Scientific and Engineering Work at Storelv

Significant accomplishments and investigations included:

1. Location and marking of an 11, 500-foot runway centerline. This proposed runway site is considered suitable for hasty construction of a long runway. The centerline is marked by orange flags at intervals of 500 feet.

2. Detailed topographic survey of the proposed runway site by T-2 theodolite. The surveyed area is approximately 12, 000 feet x 500 feet.

3. Measurement of thickness of vegetation and silt mantle on the proposed runway site. Thickness was measured at 116 stations spaced 100 feet apart along the 11, 500-foot centerline.

4. Investigation of soil conditions on the proposed runway site including excavation of soil test pits, partial measurement of soil shearing strength, and collection of soil samples for identification and laboratory determination of grain size distribution, plastic limit, liquid limit, and plasticity index.

5. Investigation of subsurface temperature and drainage conditions on and near the proposed runway site including ground temperatures and moisture content in the active zone, depth to frozen ground, and preliminary investigation of frost cracks.

6. Location and hasty investigation of three alternative sites for emergency airstrips at least 4000 feet long.

7. Location on opposite sides of Storelv of two short landing strips for a light plane such as the Dornier (DO-27). The shorter of these, 750 feet x 50 feet, was tested by two landings; the longer is about 850 feet x 50 feet.

8. Completion of a preliminary surficial geologic map of the Storelv area including a field check of aerial photo interpretations, hasty investigation of sources of construction materials, determination of terrace levels, and engineering geology of possible landing sites.

9. Investigation of water supply in the Storelv area, including collection of stream and lake water samples for chemical analysis and location of an easily accessible source of water in winter.

NATURAL FEATURES OF SURVEYED LANDING SITE NEAR STORELV

Location

The surveyed landing area is located near the center of the large peninsula north of Kejser Franz Joseph Fjord in the broad lowland that lies at the juncture of Hudson Land, Moskusokselandet, Gauss Halvø, and Hold With Hope (Fig. 1). The area is approximately midway between the heads of Loch Fyne and Moskusoksefjord. The surveyed site for a runway over 10,000 feet long is oriented approximately N15° W. An alternative site that requires further investigation is oriented approximately N75° E. The two sites are perpendicular to each other and cross near their midpoints. The northwest end of the proposed runway is about 4 miles west of Loch Fyne and 4 miles northeast of Moskusoksefjord. This point, near the campsite and cache, is located at about latitude 73°40'20"N, longitude 22°03'30W. The exact location of the site is shown in Fig. 6.

Accessibility

The Storelv site lies on the air route between Mesters Vig and Nord, approximately 106 statute miles (92 nautical miles) from Mesters Vig and 562 statute miles (488 nautical miles) from Nord. It also lies on a direct air route between Nord and Keflavik, Iceland, being approximately 670 statute miles (582 nautical miles) from Keflavik. The site is easily accessible to planes flying along the east coast of Greenland between Nord and either Mesters Vig or Keflavik. It is well-situated to be an emergency alternate for Mesters Vig, as it is closer to that station than any other established airfield.

The area is accessible by seaplanes during most of July and August. The heads of Loch Fyne and Moskusoksefjord are suitable for seaplane landings. Surface vessels could normally reach the head of Moskusoksefjord within 4 miles of the site in late July or August. Any ship that reached Mesters Vig could normally proceed to Storelv with

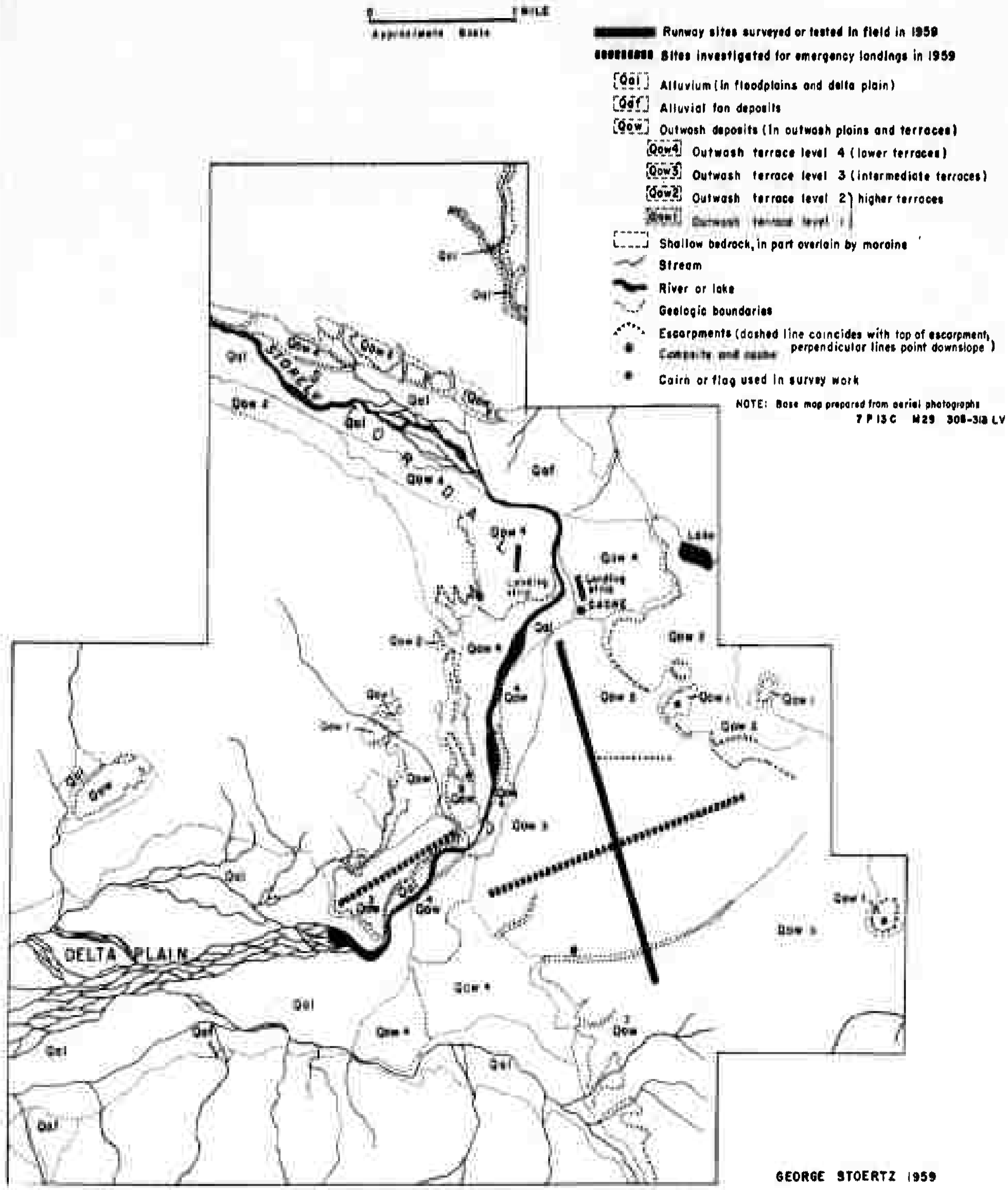

Figure 6. Surficial geologic map of the Storelv area, East Greenland, showing location of sites investigated in 1959.

little difficulty by way of the inner fjord route (Kong Oscar Fjord - Antarctic Sund - Kejser Franz Joseph Fjord - Nordfjord - Moskusoksefjord). This inner fjord region is generally navigable from July to September even though the mouths of the fjords are frequently blocked by pack ice.

Landforms and Surficial Geology

Landforms and surficial geology of the Storelv area are delimited on Fig. 6. The landing areas are in a broad low valley that extends eastward from the narrower valleys of Stordal and Moskusoksefjord. The principal river in the area is Storelv, which flows southeastward through Stordal, a steep-sided glacial valley, then abruptly bends southward and westward into the delta plain at the head of Moskusoksefjord. Along its lower course, shown on the map, Storelv is bordered by a series of terraces composed of gravel and sand outwash deposits. There are at least four prominent terrace levels, ranging from about 6 to 200 feet above the level of Storelv. Several of these terraces are possible sites for emergency aircraft landings.

The most prominent outwash terrace is at an intermediate level, forming bluffs about 40 feet high for a distance of about 2 miles along the east side of Storelv and a distance of 1 mile along the west side. From the bluff which borders Storelv, these outwash deposits extend southeastward for more than 3 miles, forming a level plain of about 8 square miles in areal extent, which occupies most of the broad valley southeast of Storelv. Two orientations for 10,000-foot runway sites have been proposed near the northwest end of this plain; at least one of these is a potential site for hasty airfield construction. Another possible site for a 4000-foot landing area (possible Site No. 4, p. 94) is situated on a detached segment of the same plain which forms a prominent terrace northwest of Storelv near its mouth.

Another prominent outwash terrace, about 100 feet above Storelv, occupies an extensive area around the southeast end of Stordal. Segments of at least 1 square mile in areal extent are found on both sides of Storelv near the point where it turns southward. These are thought to afford possible sites for 4000-foot landing strips (possible Sites 2 and 3, p. 93-94), and at least one is a potential site for hasty airfield construction.

Along the last 6 miles of its course Storelv is bordered by low terraces at various levels, mostly less than 40 feet above the river level. Unlike the higher and more prominent outwash terraces described above, the lower terraces are discontinuous and often not concordant on opposite sides of the valley. These terraces are composed predominantly of gravel and sand similar or identical to the outwash deposits underlying the higher terraces. However the lower terraces are not well-suited for long landing strips because approaches are generally restricted by the valley sides and because otherwise flat areas are generally broken by low terrace scarps. On the other hand there are numerous good sites for landing strips less than 1000 feet in length. In 1959 suitable areas for landing a light plane (DO-27) on the unimproved ground surface in late summer were found on low terraces only about 18 feet and 6 feet above the level of Storelv. These sites are shown on Fig. 6 near the cache and campsite. In 1960 the high terrace east of the campsite (Qow 2 on Fig. 6) was used for preliminary landings by light plane; all later landings were on the low terrace.

The flood plain of Storelv is composed largely of gravel and sand very similar to the outwash deposits exposed in the terrace scarps which border it. Storelv still carries some glacial meltwater from the glaciers of Hudson Land. In areas where the flood plain is wide enough to be considered as a site for aircraft landings the river is braided and the flood plain is traversed by numerous shallow channels and frequent scarps 1 or 2 feet high. These would prevent aircraft landings on the natural surface throughout the year. The same is true of the river flood plain shown in the south-central part of the map area (Fig. 6).

The valley floor at the head of Moskusoksefjord is an extensive delta plain about 3 miles long and 1 1/2 miles wide. It is composed largely of silt and sand as well as some gravel concentrated where Storelv and other streams enter the plain. In summer the area is too soft to safely support aircraft landings, but when the ground is frozen or snow-covered there are numerous smooth areas favorable for aircraft operations. One of these is in a northwest-southeast direction near the northeastern border of the plain starting from the base of the 40- to 55-foot outwash terrace and extending about 5000 feet to the northwest.

There is a large alluvial fan on the north side of Stordal near the point where Storelv turns southward. Here streams draining the south slope of Nordhoek Bjaerg debouch onto the lowland of Stordal. The fan, composed largely of gravel, cobbles, and boulders, is traversed by numerous radiating distributary channels 1 to 6 feet deep, frequently with raised edges or levees of cobbles and pebbles. The fan is apparently active during the melt season, but by late summer there is no visible flow of water on the surface.

The lowland is bounded on the north, west, and south by low hills which are underlain at shallow depth by bedrock generally covered by a thin mantle of ground moraine and wind-blown silty sand. The terrain of these areas varies from hummocky to gently rolling, with occasional glacial erratic boulders scattered over the surface. There are a few low morainal ridges, for example near the center of the map area (Fig. 6), immediately west of the outwash deposits. Uphill from the gently rolling terrain the slopes are concave upward and become gradually steeper, passing into steep bedrock mountain slopes of Nordhoek Bjaerg in Hudson Land to the north, Salevebjaerg in Moskusokselandet to the west, and Ladderbjaerg in Gauss Halvø to the south. To the west and northwest the bedrock is principally gneiss of Precambrian age; to the south and northeast the rock is chiefly basalt of Tertiary age. The contact between basalt and gneiss probably runs across the lowland from northeast to southwest in the general vicinity of Storelv where the river follows a northeast-southwest trend. The only rock outcrop found in the lowland is basalt, exposed near the narrows of Storelv, about 1 1/2 miles southwest of the campsite and cache. The lower slopes of the basalt mountains are characterized by parallel bedrock terraces defended by successive flows of basalt. These are especially well-developed east of Loch Fyne, on the west side of Hold With Hope, and are also visible at the southeastern end of Nordhoek Bjaerg. Slopes in the gneiss areas are generally steep, and planes of gneissic foliation are plainly visible from the air or aerial photographs since small streams and gullies are oriented along them.

Microrelief and Vegetation

Outwash deposits and low rolling terrain throughout the area are generally covered by typical tundra vegetation, which consists of a growth of mosses, lichens, grasses, and other herbaceous plants that form a resilient turf 2 to 6 inches deep. The surface is generally covered by hemispherical hummocks consisting of shaggy clumps of turf with a soil core, apparently resulting from differential frost heaving within the mantle of silty fine sand. The size of the hummocks is one of the most critical factors in determining suitability of areas for aircraft operations. In most parts of the main outwash terrace (Qow 3 on Fig. 6) the hummocks are thought to be too large to permit safe landings and takeoffs even by planes of the C-130 type. Some typical dimensions noted in various places are tabulated as follows:

Diameter of hummocks	Height of hummocks
6 to 11 inches	3 to 4 inches
10 to 18 inches	5 to 7 inches
14 to 24 inches	5 to 8 inches
36 inches	8 inches

In some areas, possibly where the mantle of wind-deposited silty sand is thinnest, the hummocks would be small enough to permit safe landings and takeoffs by a C-130, provided that the length of the area was sufficient and other safety factors adequate. In such areas the typical dimensions of hummocks are thought to be 6 to 12 inches in diameter and 2 to 6 inches high (Photograph 12). Such an area is found along the 11,500-foot strip, extending from 4000 feet to about 6500 feet from the northwest end of the strip. In winter, 6 inches of snow cover on the tops of hummocks is considered sufficient to permit safe ski-landings by light planes. Even when the ground is free of snow it is reported that skis, retracted a few inches above the tire tread, may assist in landing some planes with small tires (such as the Dornier, DO-27) on hummocked areas.

Photograph 12. Typical surface near center of 11,500-foot runway site near Storelv, showing typical size of hummocks that occur from 4000 to about 6500 feet from the northwest end of the strip. Typical dimensions of the hummocks shown are 6 to 12 inches in diameter and 2 to 6 inches high. Hummocks of this size would probably permit safe landings and takeoffs by planes of the C-130 type. View is S15°E, along the centerline, near its midpoint. Date: 1 September 1959.

Hummocks are larger and better developed on the higher outwash terraces. On the lower terraces, less than 40 feet above the flood plain of Storelv, there are several areas over 750 feet long in which hummocks are small enough to permit safe landings and takeoffs. On the higher terraces, 40 or more feet above Storelv, safe areas are infrequent, although at least two suitable areas up to 2500 feet long have been located on the main terrace (Qow 3 on Fig. 6) and the higher terrace (Qow 2 on Fig. 6).

The vegetation mat that covers nearly all possible landing sites in the Storelv area is locally an aid to aircraft operations since it affords some support in areas of soft soil and would permit one or two traverses by aircraft in some otherwise untrafficable areas. However the 1960 party has noted that the vegetation mat would be a hazard where it is thick enough to prevent rutting adjacent to a number of soft areas where rutting would be inevitable. The shearing strength of the turf cannot be adequately measured by cone penetrometer since the point easily penetrates the porous mat by displacing rather than breaking vegetation fibers, while an airplane tire would first compress the vegetation and then be supported until the fibers were torn apart.

Flood plains, alluvial fans, and the delta plain at the head of Moskusoksefjord are largely devoid of vegetation, although some of the higher areas have a thin vegetation cover. Other areas lacking vegetation include windswept areas and steep slopes such as the edges of outwash terraces.

Topography

Slope and relief. Microrelief features having a relief of less than one foot (i.e., the soil hummocks) are described above; features having a relief of more than one foot are described below. The surveyed runway site (Fig. 7) slopes almost imperceptibly toward the southeast at an average longitudinal slope of 0.4 percent. A shallow stream channel, incised 8 feet below the general level of the surrounding area, crosses the runway from 1050 to 1300 feet from the southeast end. This gully would require about 5000 cubic yards of fill to permit utilization of the southeastern 1300 feet of the runway. Other features having a relief greater than 2 feet are shown on Fig. 8. The following relief features are present, listed in order from the northwest end of the runway:

1,400 feet: low escarpment 2 feet high oriented approximately N50°W, sloping downward toward the southwest.

3,800 feet: low elongate mound 2 feet high, 10 feet wide, and 50 feet long, oriented approximately east-west.

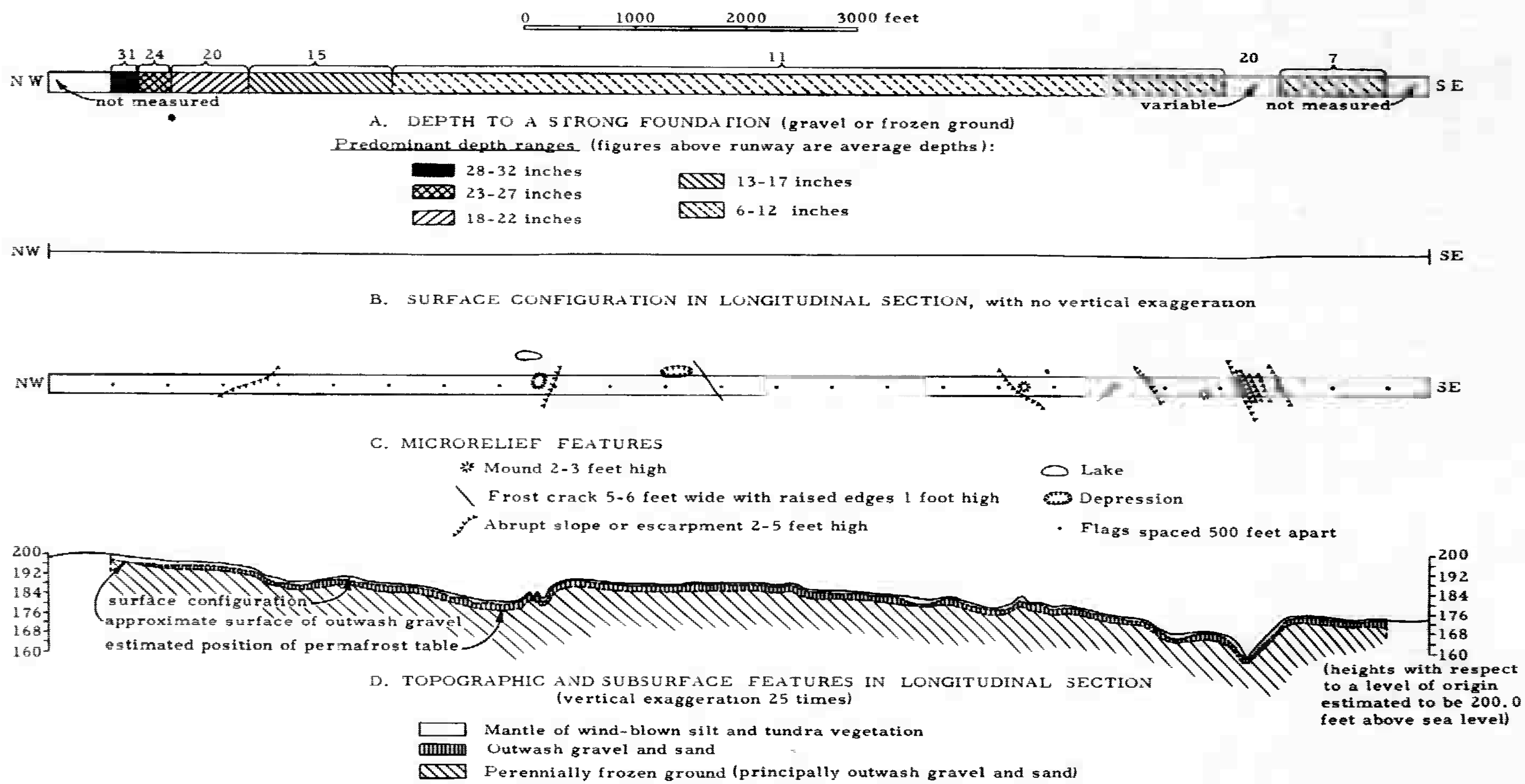

Figure 8. Natural features of surveyed airstrip near Storelv, East Greenland.

3,900 feet: elongate mound 3 feet high, 15 feet wide, and 100 feet long, oriented approximately east-west.

4,000 feet: escarpment 4 to 5 feet high oriented approximately east-west, sloping downward at about 15 percent toward the northwest.

5,400 feet: frost crack 6 feet wide, up to 2 feet deep, and with raised edges about 6 inches high, oriented approximately N30°E (Photograph 13).

8,300 feet: mound 3 feet high, 30 feet in diameter.

9,100 feet: frost crack 5 feet wide with raised edges about 6 inches high, oriented approximately N60°W.

9,500 feet: escarpment 4 to 5 feet high oriented approximately N45°E, sloping downward at about 5 percent toward the southeast.

10,000 feet: low mound 1 1/2 feet high, 20 feet in diameter, located 60 feet southwest of centerline.

10,200 to 10,450 feet: stream valley 8 feet deep, oriented approximately N45°E.

10,500 to 10,700 feet: slope of approximately 4 percent upward toward the southeast.

Dimensions and orientation. The surveyed runway site is 11,500 feet long and 200 feet wide. It is oriented approximately N15°W (Photograph 14). The alternative site, not yet investigated in detail, is approximately 10,000 feet long and is oriented approximately N75°E.

Approaches and glide angle. Air approaches are suitable from either end of both the proposed and the alternative runway sites, provided that the area is used for landing strips no longer than about 6000 feet. If the runway is over 6000 feet long, approach from the northwest is restricted by the north side of Stordal.

From the northwest, approach is via Stordal. The north side of Stordal lies about 11,000 feet from a touchdown point located 4000 feet from the northwest end of the runway allowing a glide path 10,000 feet long and a glide angle of 2 percent. If the touchdown point were placed at the northwest end of the surveyed 11,500-foot strip, approach would be obstructed by the hillside 7000 feet to the northwest. This would permit a glide path (at 2 percent slope) of only 7000 feet, which is inadequate, and would permit no level entrance zone beyond the glide

Photograph 13. Frost crack that crosses center of surveyed runway site at Storelv. The centerline of the surveyed strip crosses the middleground, intersecting the frost crack at a point 5400 feet from the northwest end. Gravel lies within 3 inches of the surface under the raised edges of the crack, but is about 1 foot below the depressed center. Three or four similar features cross the 11,500-foot strip. Date: 1 September 1959.

Photograph 14. View along the surveyed runway at Storelv after snowfall. View is from the northwest corner, looking southeast. The flag in the foreground marks the corner of the strip, which is 200 feet wide. The centerline extends into the background and to the right, marked by flags spaced 500 feet apart, at least two of which are visible near the corner-marker. Date: 5 September 1959.

path. For this reason the northwest approach to the site must be considered inadequate for a landing strip longer than about 6000 feet or for a landing strip that starts within 3000 feet of the northwest end of the 11,500-foot strip.

From the south, approach to the surveyed strip is via Badlanddal, the valley between MacKenzie Bugt and Loch Fyne. Approach from this direction is unobstructed, allowing the required glide path at a slope of 2 percent for a distance of 10,000 feet, and beyond that a level approach zone for at least 3 miles.

Approaches to the alternative strip are unobstructed for distances of at least 5 miles to the northeast and southwest, via Loch Fyne and Moskusoksefjord respectively. From either direction a 10,000-foot glide path (at 2 percent slope) and a 15,000-foot level approach zone would be possible.

Drainage

The outwash terrace on which the landing sites are located drains to the southwest (?) into Moskusoksefjord. Because of the low slope of the surface and the small lakes near the runway, drainage may be a problem during the melt season (late May to July). At that time the mantle of vegetation, silt, and fine sand is probably saturated with melt-water from the melting snow and thawing ground. This mantle would be too soft to support repeated traverses by heavy aircraft, even in areas where the soil hummocks are small enough to permit safe landings; this is true throughout the summer at any moisture content, since the soil has little plasticity and a low shearing strength whether dry or wet. After several traverses the wheels of heavy aircraft (such as a C-124) would probably sink into the soft surficial mantle until supported by a firm foundation such as frozen ground or outwash gravel. Therefore neither the surface drainage, the moisture content, nor the shearing strength of this surficial soil layer is the critical factor in determining suitability of the area for repeated traverses by heavy aircraft. Instead the most critical factors are the size of the soil hummocks and the thickness of the surficial mantle, discussed elsewhere.

Meteorological Conditions

Detailed weather records are available for at least 5 years from the Myggbukta station, located on the north shore of MacKenzie Bugt 15 miles southeast of the landing site, at an elevation of about 13 feet. It is uncertain how representative this coastal station is of conditions in the Storelv area, which is about 20 miles inland and would therefore be expected to have colder winters, warmer summers, slightly less precipitation, less cloudiness, and less fog. The following summary of weather is based largely on a 5-year period of record from Myggbukta; statistical data are summarized in Table 7.

Table 7. Summary of meteorological data for Myggbukta, East Greenland.

MONTH	TEMPERATURE					PRECIPITATION			WIND	CLOUDINESS				FOG
	Abs. max. °F	Mean daily max. °F	Mean °F	Mean daily min. °F	Abs. min. °F	Mean days with prec. 1/	Mean monthly prec. (in.)	Mean days with snow 2/	Average speci- fied wind speed (mph)	Mean monthly cloudi- ness (%)	Mean clear days 3/	Mean partly cloudy days 3/	Mean cloudy days 3/	Mean days with fog
JAN	34	26	-5	-33	-39	7	1.1	7	10	42	12	11	8	0
FEB	41	28	-7	-41	-48	4	0.6	4	8	48	10	10	8	1
MAR	36	27	-6	-32	-41	5	0.6	5	6	50	9	14	8	1
APR	45	32	2	-29	-36	3	0.3	3	5	41	11	14	5	1
MAY	53	41	19	-1	-10	4	0.5	3	5	50	8	14	9	2
JUN	66	59	31	24	21	3	0.5	1	6	64	5	13	12	6
JUL	69	61	39	29	27	4	0.6	0	7	60	6	13	12	6
AUG	59	56	37	26	23	5	1.4	1	6	65	4	17	10	7
SEP	50	46	28	12	4	5	1.3	3	8	56	4	20	6	4
OCT	47	39	15	-10	-23	4	0.8	4	9	49	9	14	8	0
NOV	35	28	4	-19	-31	6	0.8	6	11	56	4	20	6	...
DEC	38	27	-2	-30	-36	6	0.9	6	9	49	11	10	10	...
Annual	69	39	13	-9	-48	56	8.7	44	7	52	93	170	102	28 or more
Yrs. Rec.	5	5	11	5	5	5	5	5	...	...	...	...	...	...

1/ 0.04 inch or more
2/ 0.004 inch or more
3/ Undefined

Mean monthly temperatures at Myggbukta are below freezing 10 months of the year, from September until June, and mean daily minimum temperatures are below freezing during every month. Daily minimum temperatures at Storelv would be expected to be somewhat higher in summer than at Myggbukta, but the frost-free period probably does not exceed a few weeks. This is in sharp contrast with areas of continental climate such as Brønlund Fjord. In spite of the fact that this station is 600 miles north of Myggbukta and has a mean annual temperature 9F° lower, it has a frost-free period about 2 1/2 months long (mid-June to late August), perhaps 10 times as long as the frost-free period at Myggbukta. Summer temperatures at Myggbukta are as cold as those recorded at any other weather station on ice-free land areas in Greenland. The transition from predominantly freezing temperatures to predominantly thawing temperatures at Myggbukta is extremely slow and the period of frequent alternation between freezing and thawing temperatures is very long, lasting at least 6 1/2 months (mid-April to late October). In fact temperatures both below freezing and above freezing have been recorded during every month of the year at Myggbukta in contrast to only four months of the year at Brønlund Fjord. It would be expected that the ground would freeze and thaw very slowly at Myggbukta, allowing meltwater ample opportunity for drainage. The ground surface begins to freeze in early September but probably is not frozen deeply enough to support heavy aircraft until the end of October.

Annual precipitation is about 8.7 inches, about three-fourths of it falling during the 6 months from August to January. Precipitation was recorded on an average of only 15 percent of the days throughout the year, being most frequent during the 6 months from August to January, as might be expected. More than a trace of snow was recorded on only 44 days per year, principally during the 6 months from October to March. There is little information on snow depths, but it is estimated that average snow depths do not usually exceed 1 or 2 feet during the month of greatest depth.

High winds occur throughout the year but are most common during the 6 months from September to February, during which period wind speed averages 9 mph at Myggbukta. In the Storelv area there are some indications that there have been strong northwest winds blowing out of Stordal. The mantle of wind-deposited silt and fine sand that covers the entire landing site is thickest near the northwest end of the proposed airstrip where it averages 31 inches thick, and becomes progressively thinner toward the southeast, where it averages only 7 inches thick. There are several blowouts at the east end of Stordal on a low terrace 15 to 18 feet above the level of Storelv. Strong winds and possibly wind-blown sand and dust may occasionally be a hazard to aircraft in the Storelv area.

A lower percentage of cloudiness and a lower incidence of "cloudy days" have been recorded at Myggbukta than at most other coastal stations in Greenland. The cloudiest period of the year is during the three summer months (June to August), during which time mean cloudiness is about 63 percent, and an average of 11 days per month are recorded as "cloudy."

Neglecting local topography, the sun is continuously above the horizon at the latitude of Myggbukta for about 3 1/4 months, from about 3 May to 10 August. The sun is below the horizon for about 2 3/4 months, from 9 November to 2 February. There is only a very short period in late December when there are days without some period of civil twilight (sun less than 6° below the horizon).

Soil Conditions

Soil type and soil section. The proposed landing site is covered by a 2- to 6-inch mat of living plants and dead organic matter that has been described under the heading microrelief and vegetation. This forms a resilient turf characterized by hemispherical mounds or soil hummocks 6 to 36 inches in diameter and 2 to 8 inches high. In some areas the hummocks are small enough to permit safe landings and takeoffs by aircraft. In such areas the typical dimensions of hummocks are about 6 to 12 inches in diameter and 2 to 6 inches high (Photograph 12).

Beneath the turf is a layer of wind-deposited silt and fine sand 2 to 30 inches thick. This soil is identified as silty fine sand (engineering soil type SM), containing 30 percent silt or clay, 62 percent fine sand, and 8 percent medium sand. Since neither the turf nor the silty-sand mantle are capable of supporting repeated traverses by heavy aircraft the combined thickness of these two layers (i. e., the depth to a firm gravel surface) is one of the critical factors in determining suitability for aircraft landings. This combined thickness ranges from 4 to 32 inches under the surveyed runway area, being thickest at the northwest end and decreasing irregularly toward the southeast. The variations in thickness along the runway are shown in Fig. 8 and summarized in Table 8.

The silty-sand mantle is underlain by at least 40 feet of gravel and sand outwash deposits (Photograph 15). Where these deposits were observed and sampled in the edges of terraces near the airstrip, the uppermost layer of outwash was found to be poorly graded gravel (engineering soil type GP), containing about 25 percent cobbles, 30 percent coarse gravel, 25 percent fine gravel and coarse sand, 15 percent medium sand, and about 5 percent finer materials that probably sifted down into the gravel from the overlying silty-sand mantle. In the upper layers of outwash gravel, most pebbles and cobbles are coated with

Table 8. Variations in thickness of turf plus silty-sand mantle on surveyed airstrip near Storelv, East Greenland.

Distance from southeast end of runway	Thickness of turf plus silty-sand mantle 1/	
	Average thickness	Predominant range of thickness
0 - 950 feet	7 inches	4 - 11 inches
950 - 1,450 feet	variable	variable
1,450 - 8,950 feet	11 inches	6 - 12 inches
8,950 - 10,250 feet	15 inches	13 - 17 inches
10,250 - 10,950 feet	20 inches	18 - 22 inches
10,950 - 11,250 feet	24 inches	23 - 27 inches
11,250 - 11,500 feet	31 inches	28 - 32 inches
ca. 11,600 feet (in test pit)	36 inches	36 inches

1/ The thickness of turf plus silty-sand mantle was measured with a cone penetrometer at 116 stations spaced 100 feet apart along the centerline of the surveyed airstrip. The combined thickness of turf plus silty-sand mantle, as discussed here and elsewhere in this report, is the thickness from the top of soil hummocks down to the point where the upper level of outwash gravel is sufficiently compact to give a cone index reading of 420, equivalent to a CBR of at least 15. Therefore the thickness is a maximum value, including the maximum thickness of spongy turf, and in some areas also including 1 or 2 inches of loose gravel that might not support the heaviest aircraft. Since the wheels of an aircraft would normally compress the turf to a depth of about 2 inches and would not sink to the maximum depths recorded, a safety factor of 2 to 4 inches is included wherever mantle thicknesses are described in this report.

caliche which locally cements adjacent pebbles together and adds considerable strength to the soil. Some lower horizons in the outwash are composed of poorly graded sand (engineering soil type SP), containing about 15 percent coarse sand, 80 percent medium sand, and 5 percent fine sand. The outwash as a whole seems well-graded, containing a good proportion of all grain sizes from medium sand to cobbles. This material would be a good source of sand and gravel for construction, although the effect of caliche coatings and constituent rock types on its suitability as aggregate would have to be investigated.

A generalized longitudinal section showing observed and inferred subsurface features along the centerline of the proposed runway is shown in Fig. 8. The outwash gravel is perennially frozen at a depth of about 3 feet below the surface. Representative soil sections from the surface down to frozen ground are shown in Table 9.

Photograph 15. Abundant sand and gravel for construction can be obtained from the edges of outwash terraces within one mile of all possible airfield sites in the Storelv area. Steep, bare, south-facing slopes such as this one have a deep permafrost table, permitting easy excavation during summer. View: WNW from point 2 3/4 miles southwest of campsite. Date: 6 September 1959.

Plasticity characteristics. The silty fine sand mantle that covers the landing area has an extremely low plasticity and consequently has little shearing strength when either dry or wet. The soil has a liquid limit of about 22 percent, a plastic limit of about 20 percent, and a plasticity index of only 2. This low plasticity index, which is the numerical difference between the liquid limit and the plastic limit, indicates that the soil has the physical properties of a plastic in only a very narrow range of soil moisture contents, from 20 percent to 22 percent. If the soil moisture content exceeds 22 percent it will have the physical properties of a liquid and afford practically no support to a vehicle. But even when the soil is dry it will provide only 1/2 to 3/4 of the bearing strength required to support repeated traverses by a heavy aircraft, as discussed below under the heading Soil strength.

Soil strength. Partial measurements of soil strength were made by a cone penetrometer designed and constructed by the Waterways Experiment Station, U. S. Army Corps of Engineers, Vicksburg, Mississippi. Strength was measured directly as cone index, a measure of bearing capacity and traction capacity of the surface. These readings can be converted by graph into the equivalent CBR values 4/. With the cone penetrometer, a 210-pound operator can measure cone index values as high as about 420, equivalent to a CBR of about 15. These maximum values are considerably higher than the minimum CBR of 6 (cone index about 160) required for two landings and takeoffs (one coverage) of a C-124 cargo plane, and much higher than the minimum CBR of about 5 (cone index about 130) required for a C-130 cargo plane.

The gravel and sand outwash deposits on which are situated all potential landing sites in the area, have a uniformly high bearing strength equivalent to a CBR of at least 15. At least locally the upper layer of outwash is coated and partly cemented by a caliche-like deposit, adding some strength to this layer. The extent of this is not known because it is covered by a mantle of vegetation and wind-deposited material. The surface of the gravel is stabilized by silt and fine sand that has sifted down into the gravel from the overlying mantle. The gravel terraces, stabilized as they are by permafrost and a mantle of wind-deposited fines, would provide a strong natural foundation for an airfield or heavy installation.

4/ Approximate relationship between CBR and cone index is shown by graphs in AFCRC, Air Force Surveys in Geophysics No. 77, 1955, Remote determination of soil trafficability by the aerial penetrometer, by C. E. Molineux, 46 p.

Table 9. Soil sections in the Storelv area, East Greenland.

A. Soil section in area of exceptionally deep silt near main airstrip

Date: 31 August 1959
Location: Test pit about 100 feet northwest of northwest end of surveyed 11,500-foot airstrip.

Depth	Description	Depth	Soil temp.	Moisture content
0- 2 in.	Vegetation and organic matter	1-2 in.	42°F(air)	10.1%
2-36 in.	Silty fine sand (soil type SM) containing 30% silt or clay, 62% fine sand, 8% medium sand, and 0.4% coarse sand; soil is soft, moist, and uniform throughout section.	6 in. 12 in. 18 in. 24 in. 30 in.	34°F 33.5°F 33°F 33°F 32.5°F	9.6% 9.7% 15.9% 17.9% 9.6%
36 in.	Frozen ground	36 in.	32°F	11.6%

B. Soil section in area of exceptionally deep silt near short airstrip

Date: 31 August 1959
Location: Test pit at campsite near 750-foot landing strip for Dornier (DO-27)

Depth	Description	Depth	Soil temp.	Moisture content
0- 4 in.	Vegetation and organic matter	1-2 in.	36°F(air)	6.9%
4-37 in.	Silty fine sand (soil type SM) containing 94% silt, fine sand, or clay, and 6% medium sand; soil is soft, moist, and uniform throughout section. Thickness of silt has been increased by solifluction of silt mantle from the edge of the terrace immediately south of the campsite.	6 in. 12 in. 18 in. 24 in. 30 in.	34°F 33.5°F 33°F 33°F 32.5°F	12.1% 18.2% 18.0% 8.1% 17.2%
37 in.	Frozen ground	37 in.	32°F	....

C. Soil section in edge of outwash terrace on which main airstrip is situated

Date: 1 September 1959
Location: Test pit in edge of terrace 400 feet northwest of northwest end of surveyed runway.

Depth	Description	Soil temperature	Moisture content
0- 3 in.	Vegetation and organic matter	Soil temperatures not recorded because of proximity to terrace scarp which distorts thermal profile; permafrost not exposed in section.	Soil moisture content not recorded because of proximity to terrace scarp which has allowed better subsurface drainage than normal; section dry, unfrozen.
3-24 in.	Silty fine sand (soil type SM)		
24-36 in.	Poorly graded non-frost-susceptible gravel (soil type GP) containing about 25% cobbles, 30% coarse gravel, 25% fine gravel and coarse sand, 15% medium sand, and 5% finer material (chiefly silt and fine sand) that probably sifted down from overlying silty sand mantle.		
3-40 ft. or more	Outwash gravel and sand containing alternating layers of poorly graded gravel (soil type GP) and poorly graded sand (soil type SP). Typical layer of poorly graded sand is 15% coarse sand, 80% medium, and 5% fine.		

Table 9. (continued)

D. Soil section under raised edge of frost crack that crosses main airstrip (Photograph 6)			
Date: 1 September 1959 Location: Test pit 5400 feet southeast of northwest end of airstrip, 100 feet northeast of centerline.			
Depth	Description	Depth	Soil temperature
0- 2 in.	Vegetation and organic matter	Surface (air at ground)	37°F
2- 3 in.	Silty fine sand (soil type SM)	...	...
3-54 in.	Poorly graded gravel (soil type GP) outwash containing many cobbles.	6 in. 12 in. 24 in. 36 in.	34.5°F 34°F 33.5°F 33°F
54 in.	Frozen ground	54 in.	32°F

E. Soil section under depressed center of frost crack that crosses main airstrip (Photograph 6)			
Date: 1 September 1959 Location: Test pit 5400 feet southeast of northwest end of airstrip, 100 feet northeast of centerline.			
Depth	Description	Depth	Soil temperature
0- 4 in.	Vegetation and organic matter	Surface (air at ground)	43°F
4-12 in.	Silty fine sand (soil type SM) penetrated by a few roots from overlying vegetation.	6 in. 12 in.	33°F 33°F
12-36 in.	Poorly graded gravel (soil type GP) outwash containing many cobbles.	18 in. 24 in.	32.5°F ±32.2°F
36 in.	Frozen ground	36 in.	32°F

The wind-deposited silt and sand that covers the outwash gravel has a very low bearing strength in summer, varying with seasonal changes in moisture content. It is estimated 5/ that on the surveyed airstrip a soil strength equivalent to a CBR of 5 is attained at an average depth of 3 inches, a CBR of 6 at an average depth of 5 inches, a CBR of 8 at an average depth of 7 inches, and a CBR of at least 15 at the upper surface of the outwash gravel (an average depth of 9 inches under the central 3000 feet of the surveyed airstrip). These depths include the maximum thickness of the turf encountered in the centers of hummocks. Compression of this turf under the wheels of a heavy aircraft might reduce the effective depths by about 2 inches. The above estimates of CBR do not reflect the strength of the turf which could not be adequately measured with a cone penetrometer. This would probably have to be measured with a CBR testing device or some other device having a penetrometer cylinder at least 3 inches in diameter.

Permafrost and subsurface drainage conditions. In early September frozen ground underlies the landing site at a depth of 3 feet. At that time of year there is only a slight temperature gradient from the surface down to frozen ground, so the upper level of frozen ground must correspond closely to the permafrost table, below which the ground remains perennially frozen.

In test pits, soil temperatures decreased fairly regularly from the surface down to permafrost. On 31 August - 1 September, when air temperatures at the ground surface averaged about 40°F, soil temperatures averaged 34°F at 6 inches, 33.5°F at 12 inches, 33°F at 18 inches, 33°F at 24 inches, 32.5°F at 30 inches, and 32°F at a depth of 36 inches, the surface of the frozen ground.

In late August, prior to a wet snowfall that saturated the surface, moisture content of the soil increased irregularly with depth, averaging (on 31 August) about 8 1/2 percent at the surface, 11 percent at 6 inches, 14 percent at 12 inches, 17 percent at 18 inches, 13 percent at 24 inches, 13 percent at 30 inches, and about 12 percent immediately above the frozen ground. These values were obtained in areas of very thick silt and fine sand, extending all the way from the surface down to frozen

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5/ Inadequate data on shearing strength of the upper layer of the soil are available because surface of soil was frozen to a depth of 1/2 to 3/4 inch in late August and saturated by wet snowfall in early September. Soil strengths are conservatively estimated to be at least as low as that of the Nordøst Fjord Site, which had soil conditions similar to those at the Storelv Site, and which was the softest site measured in detail in East Greenland.

ground. Moisture content determinations were not made in gravel layers as they would be of little value, having little or no relationship to the engineering characteristics of the gravel.

During the short period of field work little direct information on permafrost could be obtained since the permafrost is generally overlain by firm gravel that prevents probing with either a hand-operated soil auger or a cone penetrometer, and consequently the depth to frozen ground could only be measured in test pits. The upper layers of outwash gravel are poorly graded and not frost-susceptible, since only about 1 percent of the material is finer than 0.02 mm in diameter. The fines evidently consist of material that has sifted down from the overlying mantle of silty sand.

Water supply

Storelv is located less than 500 feet from either the northwest end of the proposed landing strip, from the campsite and cache, or from either of the two short landing strips. The river is a good source of drinking water in summer (Photograph 16), but in winter would probably

Photograph 16. Storelv at period of low discharge (early September). View south in the narrows 1 1/2 miles southwest of the campsite and 1 mile downstream from Sampling Site 34. The river and its tributaries are good sources of drinking water in summer, but in winter would probably be completely frozen. Date: 3 September 1959.

be completely frozen. In late August, Storelv apparently contains little or no suspended silt; but during the melt season it may contain silt that is carried into it by meltwater streams from the glaciers of Hudson Land. At this time a small quantity of water could be obtained from a tributary near the campsite and cache. In late August, Storelv, where it flows in a single channel, is about 20 feet wide, 6 inches to 1 foot deep, and has an estimated discharge of about 100 gallons per second. During the melt season the discharge may reach several thousand cubic feet per second. In winter, when streams are frozen solid, water could be obtained from a lake located 3/4 mile northeast of the campsite and cache. This lake probably does not freeze to the bottom in winter as it is estimated to be over 6 feet deep.

EVALUATION OF SURVEYED LANDING SITE

Suitability for Emergency Aircraft Landings

Summer season. Parts of the 11,500-foot surveyed strip are considered suitable for emergency landings by aircraft of the C-130 type, but at present no specific site near Storelv can be evaluated as suitable for safe operations of such aircraft. The central part of the strip, extending from 4000 feet to about 8000 feet from the northwest end, was the best area located in 1959 for emergency landings, but further field work would be necessary to delimit the most suitable area in detail. Although that 4000-foot section is essentially flat, as shown in Fig. 7, there are surface microrelief features that may be a hazard. Soil hummocks are well-developed in the southeastern one-third of this section, while in the northwestern two-thirds they are low enough to permit safe landings (Photograph 12). In that area the hummocks are generally only 6 to 12 inches in diameter and 2 to 6 inches high, and the mantle of silty fine sand is generally 6 to 12 inches thick, averaging 9 inches. However the area is traversed by a frost crack that crosses the centerline at a point 5400 feet from the northwest end of the strip (Photograph 13). It was concluded from preliminary observations in 1959 that this feature would not constitute a serious hazard for a C-130. However subsequent investigations in 1960 resulted in the conclusion that the frost crack precluded the use of that part of the runway and that filling of the crack to the level of the surrounding area was not practicable under the circumstances. Detailed evaluations of specific sections of the strip have been deferred to the report of the 1960 field party.

Repeated traverses by aircraft would probably result in progressive deterioration of parts of the landing surface from at least three causes: (1) areas having a thick surficial mantle would develop deep ruts which would become physical obstacles to further traffic, particularly if attempts were made to cross old ruts at a small angle; (2) the turf would locally be torn up, especially in touchdown and turnaround areas, resulting in some loss of strength previously provided by the vegetation; (3) the silty soil that covers the airstrip would gradually lose shearing strength with increasing traffic since its remolding index is less than 1.0.

Winter season. In winter, when the ground is snow-covered, the central part of the surveyed airstrip is suitable for numerous traverses by heavy cargo planes. There is little available data on snow thicknesses, but it is estimated that there is generally sufficient snow to smooth out microrelief features such as hummocks and frost cracks.

Suitability for Hasty Airfield Construction

Engineering aspects. Hasty construction of an airfield meeting minimum standards would probably require stripping of an average of 12 1/2 inches of vegetation, silt, and fine sand from the surface of the surveyed 11,500-foot airstrip, grading three 2- to 5-foot escarpments to a maximum longitudinal grade of 2 percent, filling a stream channel 8 feet deep near the southeast end of the airstrip, and possibly excavating 3-foot deep drainage ditches around the perimeter of the airstrip.

Removal of the surficial mantle of vegetation and silty fine sand from the proposed landing site would expose firm outwash gravel that is not frost-susceptible (less that 1 percent of the gravel finer than 0.02 mm in diameter) and that would form a good wearing surface or an excellent natural foundation for construction. Permafrost is commonly at depths greater than the depth of the silty mantle, so excavation would be easy throughout the summer months except in those areas where the permafrost table is shallower than the silty mantle. Removal of the insulating blanket of vegetation and silt to a depth of 1 foot would probably result in thawing of the permafrost to depths about 3 feet lower than its present position. In permafrost regions there is always a possibility that such thawing will result in a local subsidence of the surface due to the melting of ice wedges or lenses within the gravel. However it is concluded that construction problems would be at a minimum in the Storelv area for the following reasons:

1. The runway surface is nearly free of prominent frost features. Only three or four frost cracks cross the runway surface and shallow excavation of the largest of these failed to reveal the presence of an ice wedge.

2. An excellent natural foundation of nonfrost-susceptible gravel underlies the entire area and extends from an average of 1 foot below the surface to a depth of at least 40 feet.

3. Soil moisture content on most of the landing strip is probably moderate to low (below 20 percent) during most of the year because of: (1) semi-aridity of the area, with mean annual precipitation of only 8.7 inches; (2) slow freezing and thawing of the ground due to the slow transition from predominantly freezing temperatures to predominantly thawing temperatures, allowing meltwater a fairly long period for drainage (assuming that the maritime climate at Myggbukta has an influence as far as Storelv); and (3) precipitation distributed in such a way that relatively little falls during the melt season when the ground surface would tend to be wettest, and a relatively large amount falls during late summer and early winter. This precipitation is primarily in the form of snow, and occurs during the period of maximum wind speed, allowing a maximum opportunity for evaporation and sublimation before the melt season.

The presence of permafrost at shallow depths probably impedes subsurface drainage of all outwash terraces in the area, as evidenced by ponds that last throughout the summer and numerous shallow swales that were reported to be soft and wet during July 1960. In order to minimize drainage problems during hasty airfield construction in the Storelv area, the following procedures are recommended:

1. In stripping vegetation and silty-sand mantle from the landing area, unnecessary working or cutting of the underlying gravel should be avoided in order not to disrupt the upper layer of gravel which is locally coated or cemented by a caliche-like deposit. Unnecessary mixing of gravel and fines should be avoided in order not to render the gravel surface frost susceptible (more than 3 percent of the material finer than 0.02 mm in diameter).

2. Unnecessary traffic or excavations should be avoided in the natural surface surrounding the landing area to prevent compression, rutting, or other disruption of the insulating blanket of turf, which might have the following consequences: (1) rapid freezing of the active layer under disturbed areas during the first winter, resulting in a blocking of subsurface drainage and consequent formation of either a surface icing during the winter or a wet untrafficable area during the melt season; and (2) rapid thawing of the ground during the first summer, possibly resulting in the formation of a poorly drained basin in the permafrost table which might become saturated with meltwater and might subsequently give rise to formation of an ice lens and/or disruptive frost action. In general, any uncontrolled disturbances of the

natural thermal regimen in a permafrost area are likely to result in self-perpetuating problems and progressive deterioration of the natural surface, and are therefore likely to increase the cost of any future construction in the area.

3. Test pits and other temporary excavations near the landing area should be promptly filled after use.

4. The following recommendation is tentative and subject to a more detailed evaluation of engineering aspects. Prior to stripping of turf and silty mantle from the landing area, drainage ditches should probably be excavated to a depth of about 3 feet around the perimeter, at least several hundred feet from the runway. These should cause a subsidence of the permafrost table under the ditch, and should intercept both subsurface and surface drainage. Excavated material should be piled into high banks on the downhill side of the ditches. In winter the ditches may locally become filled with surface ice that would otherwise form on the runway. In addition shallow ditches might be necessary around the immediate edge of the landing area. These would provide drainage from the depressed basin in the permafrost table that would form under the landing area after stripping off the insulating mantle.

Construction materials. Abundant sand and gravel for construction (Photograph 15) can be obtained from the edge of the high outwash terrace northeast of the surveyed landing area or from the shallow stream channel that crosses the southeast end of the airstrip. No part of the landing area is more than 1 mile from one of these sources. The high outwash terrace is most favorable because the south-facing steep slope of the terrace is free of vegetation and probably has a deep permafrost table, permitting easy excavation during the summer. Transport from this area to the site would be entirely downhill.

Water for construction can probably be obtained throughout the year from a lake that covers about 15 acres on the high outwash terrace, located about 1 mile northeast of the north end of the landing area. The lake is estimated to be at least 40 feet higher than the landing area, greatly facilitating piping.

OTHER POSSIBLE SITES FOR LANDING STRIPS IN THE STORELV AREA

Possible Site No. 1: Southeast of Campsite

Location. The site is 2 miles southeast of the campsite and cache, crossing the surveyed 11,500-foot site at right angles at a point 7000 feet from the northwest end.

Accessibility. Same as the surveyed 11,500-foot site.

Approaches. Air approaches to the site are unobstructed, therefore slightly more favorable for a 10,000-foot strip than the surveyed site. Approach from the northeast is over Loch Fyne, and from the southwest over Moskusoksefjord or the delta plain at its head.

Dimensions and orientation. The site is 10,000 feet long and is oriented approximately N75° E; width is ample.

Topography and landforms. The site is on a flat terrace of glacial outwash, with an overall longitudinal slope estimated less than 2 percent. Microrelief features and topography are similar to the surveyed site except that there are thought to be few features requiring grading. Results of investigations in July 1960 show that large soil hummocks, soft swales, and ponds make the site unsuitable as an unprepared airfield.

Soil characteristics. Similar to the surveyed site except that the mantle of silty fine sand probably averages a few inches shallower.

Engineering aspects. Similar to surveyed site except that: (1) natural or artificial drainage would be aided by proximity to a shallow stream channel that runs parallel to the site at a distance of about 3000 feet; (2) there would probably be less need for grading of low escarpments; and (3) there would probably be fewer cubic yards of vegetation and silty sand to be stripped from the surface in hasty airfield construction.

Construction materials. Similar to the surveyed site except that sand and gravel can be easily obtained within 3500 feet of any part of the runway from the shallow stream channel that runs parallel to it.

Water supply. Same as surveyed site.

Conclusions. The site was not investigated in detail during the summer of 1959 because of insufficient time. However subsequent analysis of field data and aerial photos suggests that this orientation may be slightly more favorable than the surveyed 11,500-foot orientation from the following standpoints: (1) slightly better air approaches for a 10,000-foot strip; (2) fewer microrelief features requiring grading; (3) slightly thinner mantle of silty sand; and (4) slightly better drainage conditions. Field investigations in 1960 indicate that the site is unsuitable as an unprepared airfield.

Possible Site No. 2: Northeast of Campsite

Location. The site is 1 mile northeast of the campsite and cache on a high outwash terrace about 100 feet above the level of Storelv.

Accessibility. Same as the surveyed 11,500-foot site; accessible from a 750-foot strip for light planes located one-half mile to the west on a low terrace 6 feet above Storelv. In 1960 light planes landed directly on Site No. 2.

Approaches. Air approach from the southwest is unobstructed over the delta plain at the head of Moskusoksefjord. Approach from the northeast is restricted by the south slopes of Nordhoek Bjaerg, only a few thousand feet to the northeast.

Dimensions and orientation. A runway about 4000 feet long appeared possible, oriented approximately N60°E. However 1960 investigations indicate only 2800 feet are usable for aircraft landings.

Topography and landforms. The site is on a high terrace of glacial outwash about 100 feet above the level of Storelv. The only significant microrelief features are thought to be soil hummocks 2 to 6 inches high.

Soil characteristics. Similar to the surveyed site. Investigations in July 1960 showed that the soil is generally too soft for heavy-aircraft landings in summer, in spite of suitable microrelief.

Engineering aspects. Similar to the best 5000 feet of the surveyed site.

Construction aspects. Sand and gravel are available from the terrace on which the site is located, which would require raising of the materials, or from the slightly higher terrace to the southeast, which would permit downhill transport of the materials.

Water supply. Water can probably be obtained throughout the year from the lake immediately northwest of the site.

Conclusions. The site was not investigated in detail during the summer of 1959 but appeared suitable for a 4000-foot emergency landing strip for aircraft approaching from the southwest. Investigations of July 1960 show that the site is suitable for landings by light planes such as a Dornier (DO-27) in summer, but that the suitable length for emergency landings of heavy aircraft is only about 2800 feet.

Possible Site No. 3: West of Campsite

Location. The site is 1 mile west of the campsite and cache on an outwash terrace 90 to 100 feet above the flood plain of Storelv.

Accessibility. Same as the surveyed 11,500-foot site except that the area is readily accessible from an 850-foot strip for light planes located one-half mile to the east on a low terrace 15 to 18 feet above Storelv.

Approaches. Air approach from the northwest is restricted to the narrow valley, Stordal. Approach from the southeast is unrestricted over Storelv and the surveyed 11,500-foot site.

Dimensions and orientation. A runway about 4000 feet long appeared possible, oriented approximately N40°W.

Topography and landforms. The site is on a high terrace of glacial outwash 90 to 100 feet above the flood plain of Storelv. Investigations in July 1960 showed that the area has too many rough hummocky areas and soft spots to be suitable for landings by a C-130.

Soil characteristics. Similar to the surveyed site.

Engineering aspects. Similar to the surveyed site.

Construction materials. Sand and gravel are available from the edge of the terrace on which the site is located. South-facing slopes, free of vegetation, are immediately southeast of the site.

Water supply. In summer, water can be obtained from Storelv, one-half mile northeast of the site. In winter, water can be obtained from the lake 2 miles east of the site.

Conclusions. The site was hastily investigated when snow-covered in early September 1959 and appeared to be a possible site for a 4000-foot emergency landing strip. Investigations of July 1960 show that the area should be removed from further consideration.

Possible Site No. 4: Southwest of Campsite

Location. The site is 2 miles southwest of the campsite and cache on an outwash terrace about 40 feet above the level of Storelv and about 55 feet above the delta plain at the head of Moskusoksefjord.

Accessibility. Same as the surveyed 11,500-foot site except that the site is about 2 miles closer to Moskusoksefjord. A field party approaching overland from Moskusoksefjord would not need to cross Storelv, which might be a significant obstacle during the melt season. The area is accessible to small planes landing on an 850-foot strip located 2 miles to the north on a low terrace 15 to 18 feet above Storelv.

Approaches. Air approach from the northeast is over the surveyed 11,500-foot site. Approach from the southwest is over the delta plain at the head of Moskusoksefjord.

Dimensions and orientation. A runway about 4000 feet long appeared possible, oriented approximately N60°E.

Topography and landforms. The site is on an outwash terrace that appears to be a dissected segment of the prominent terrace on which the surveyed site east of Storelv is situated. Investigations in July 1960 showed that the area has too many large soil hummocks, wet swales, ponds, and possibly frost boils to be suitable for landings by a C-130.

Soil characteristics. Thought to be similar to the surveyed site.

Engineering aspects. Similar to the surveyed site except that drainage might be aided by proximity to terrace scarps.

Construction materials. Sand and gravel are available from the edges of the terrace on which the site is located. South-facing slopes free of vegetation are immediately south of the site.

Water supply. In summer, water can be obtained from Storelv, immediately southeast of the site. In winter, water could be obtained from Moskusoksefjord, 3 miles to the west, or possibly from the alluvium beneath Storelv, which in late winter would probably be frozen to the bottom.

Conclusions. A hasty examination of the snow-covered area in early September indicated that the terrace might be a possible site for a 4000-foot emergency landing strip. Investigations of July 1960 show that the area should be removed from further consideration.

RECOMMENDATIONS FOR RESEARCH AND DEVELOPMENT OF STORELV AREA

Emergency Aircraft Landings

Further investigations were required to develop the full potential of the area to support aircraft landings, including: (1) landings of test or research aircraft; (2) landings of aircraft in support of scientific research parties; and (3) landings of aircraft in unforeseen emergencies such as inaccessibility of existing airfields because of weather or mechanical failure. Recommendations listed below (1 to 4) have either been carried out or have been revised on the basis of investigations during July 1960. On the basis of investigations in 1959 it was recommended that:

1. A small field party should attempt to locate a better runway orientation, along which the average thickness of turf and silty sand is only about 6 inches over a distance of at least 4000 feet and in which soil hummocks are poorly developed. This could be accomplished by probing with a cone penetrometer at intervals of 100 feet or less along the four possible runway locations described previously, as well as in spot locations in the vicinity.

2. On the selected runway site, or on the central 4000 feet of the surveyed site, if no better one is located, delimit accurately the extent of safe touchdown areas, turnaround areas, parking areas, and warm-up areas. This could be accomplished by probing with a cone penetrometer at intervals of 25 feet or less in areas having the thinnest mantle of turf and silty sand and having the smallest soil hummocks.

3. On the selected runway site, mark with flags, cloth strips, or panels the location of overrun areas, touchdown points, runway edges, halfway point, and possibly turnaround or parking areas.

4. Test land a heavy cargo plane, preferably a C-130, on the site to observe depth of rutting, effect on vegetation, and relationship of performance to thickness of mantle and size of soil hummocks. The results of the test landing would enable predictions of what other types of aircraft could be safely landed on the surface and on the many similar surfaces throughout East Greenland. This surface, since it is covered by an unbroken blanket of vegetation, is unlike those that have been tested to date by heavy aircraft in Greenland.

Hasty Airfield Construction

The following are recommended in order to prepare for the possible need for future hasty airfield construction in the Storelv area, whether for aircraft landings in support of a research station or other installation:

1. A small field party should attempt to locate a better site for construction than the surveyed runway site, preferably having a thinner silt mantle, fewer microrelief features that would require grading, and

better conditions for artificial drainage. An alternative orientation recommended for further investigation has been described previously.

2. Delimit and mark the best runway site with flags for use by a ground party, not necessarily visible from the air.

Recommendations for Research

1. Strength tests of possible landing surfaces by WES cone penetrometer or AFCRC airfield penetrometer. Study of seasonal changes of strength with changes of soil moisture content.

a. Systematic strength tests from the surface down to firm gravel or to frozen ground should be made at intervals of approximately 100 feet along the centerline of possible landing sites and at intervals of 200 feet along the edges. The tests should be made at intervals of about 2 weeks during the field season.

b. Scattered strength tests should be made on a wide range of soils throughout the area, under as wide a range of drainage, soil moisture, vegetation, microrelief features, and permafrost conditions as possible.

2. Study of engineering characteristics of soils:

a. Test pits to permafrost at intervals of approximately 1000 feet on edges of proposed runways and at scattered locations throughout the area, under as wide a range of soils, soil moisture, vegetation, microrelief features, and permafrost conditions as practicable; sampling of soil horizons in test pits.

b. Determination of grain-size distribution curve for each soil horizon by U.S. Standard sieve series supplemented by hydrometer analysis.

c. Determination of plasticity characteristics of clayey or silty soils, including liquid limit, plastic limit, and plasticity index.

d. Soil identification according to Corps of Engineers, Unified Soil Classification System, based on determinations in b and c above.

e. Determination of compaction characteristics of runway surface with WES remolding equipment. Measurement of remolding index (ratio of shearing strength after compaction to shearing strength before compaction), which is a measure of the effect of traffic on soil strength.

3. Study of permafrost and subsurface soil moisture conditions:

a. Excavation of test pits across frost cracks, frost polygons, and mounds to determine their mode of origin, especially to ascertain whether ice wedges or lenses are present.

b. Measurement of depth to frozen ground in test pits, and if possible in auger holes, at scattered locations throughout the area and at frequent intervals during the field season.

c. Measurement of soil temperatures and soil moisture in test pits, every 6 inches from the surface down to permafrost, at frequent intervals during the field season.

4. Areal geologic mapping of bedrock formations, surficial deposits, availability of construction materials, and water supply. This would include emphasis on:

a. Collection of samples of bedrock and surficial deposits. Collection of organic material from unconsolidated deposits for C^{14} age determination.

b. Study of Pleistocene geology of the area as evidenced by raised strand lines, terraces, glacial deposits, and glacio-fluvial deposits.

c. Field check of previous aerial photo interpretations of bedrock and surficial geology.

5. Miscellaneous studies of geomorphology, terrain, and the effect of terrain factors on military activities, for example:

a. Observations of the extent and origin of microrelief features (gullies, hummocks, frost features, boulders, vegetation, etc.) and their probable effect on aircraft landings and on overland movement; correlation of size of soil hummocks with thickness of silty mantle.

b. Observation of geologic processes characteristic of the area, including frost phenomena, blowing sand and dust, solifluction (soil creep), shoreline processes, and extent of seasonal flooding.

c. Vegetation: collection of botanical specimens, when practicable.

d. Ice conditions: observations of extent and, when possible, thickness of ice in fjords and lakes.

e. State of ground and drainage conditions: observations of extent of wet, moist, dry, or snow-covered ground.

6. Meteorological observations.

7. Hydrological observations.

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APPENDIX I. ANALYSIS OF SOIL STRENGTH DATA FROM EAST GREENLAND SITES

by

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APPENDIX I. ANALYSIS OF SOIL STRENGTH DATA FROM EAST GREENLAND SITES, AUGUST 1959

SUMMARY

One of the most critical factors in evaluating the suitability of an area for aircraft landings is the strength of the surficial soil layer. During August 1959, soil strength was measured at intervals on seven test strips in East Greenland, including several emergency landing sites and potential runway sites. This appendix describes the method for hastily testing soil strength and describes methods of analysis, presentation, and interpretation of test data. A statistical analysis of test data would be necessary to evaluate: (1) landing areas that are blanketed by vegetation, where important factors affecting soil strength are not visible at the surface; (2) remote landing areas that can be tested on only a few days during a single year; and (3) areas hastily tested by the aerial penetrometer.

<u>Throughout this section evaluations of surfaces are confined to the single factor of soil strength, assuming such factors as topography and microrelief are favorable; no ice-free landing sites in East Greenland are considered safe until the airstrip is selected and marked on the ground</u>. The results of strength tests at 210 locations on seven test strips in East Greenland are summarized in detail. Test results show that an extremely wide range of surficial deposits in East Greenland are strong enough to support at least one emergency landing and takeoff by cargo planes as heavy as an unloaded C-124 (up to 145, 000 lbs) on pre-selected and marked airstrips. Among the surficial deposits that are estimated to be sufficiently strong for that type of emergency use is the mantle of wind-deposited silt and fine sand that blankets extensive areas and is commonly covered by a few inches of typical tundra vegetation. Unfortunately this mantle is commonly covered by soil hummocks too large to permit safe landings, and it is difficult to locate smooth areas that are long enough for large aircraft. The possibility of making safe emergency landings and takeoffs from this widespread surficial deposit can greatly increase the safety of aircraft operations in the Arctic, provided that suitable airstrips are selected and marked on the ground.

INTRODUCTION

After the topographic features of an area have been determined to be favorable for aircraft landings the most critical factor in evaluating its suitability is commonly the strength of the surficial soil. This factor is related to such things as the maximum wheel load and contact pressure which the soil can sustain, the depth to which aircraft wheels are likely to sink, the maximum tire pressure which is safe for aircraft of a certain weight, and the maximum number of coverages that a certain aircraft can safely make over the surface. The possibility of making even one emergency landing and takeoff from an area may be highly significant and may save an aircraft and crew in the future. Therefore it is important to establish as closely as possible the critical limits of soil strength below which an area cannot safely be used for any traffic by various types of aircraft, and it is important to measure or predict as accurately as possible whether a potential landing site has a soil strength in excess of these values and during what periods of the year.

METHOD OF TESTING AND METHOD OF ANALYZING TEST DATA

When little time is available in the field, the following procedures can be used for hastily testing and analyzing soil shearing strength for purposes of comparing areas, landforms, and soil conditions, and for evaluating their suitability for supporting aircraft landings. Tests on as wide a range of arctic soil conditions as possible would be useful in evaluating suitability of these areas to support air operations. The procedures are intended for a hasty reconnaissance party of two or three people such as a helicopterborne party, where time on the ground is limited to less than an hour and equipment limited to less than 100 pounds, such as in the 1959 East Greenland operations.

Measurement of Cone Index or Aircraft Index on Potential Landing Strips

At stations along the centerline, measure cone index or aircraft index at 1-inch intervals from the surface down to a depth of at least 1 foot by means of the cone penetrometer designed by Waterways Experiment Station or the airfield penetrometer designed by AFCRC. The intervals between test locations should be uniform or in even hundreds of feet to prevent a subjective factor from entering into selection of test locations and to assist in statistical analysis of data. In any case the distances between stations should be paced and recorded, as the distance is as important as the cone index 6/ values in determining the appropriate weight to be given each reading. In the vicinity of each test station three or four penetrations should be made and the cone index values at similar depths averaged to arrive at a single value for each

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6/ Cone index and aircraft index are directly related (AI = 50 x CI) and measured by similar instruments. Further mention of aircraft index is omitted in this report for the sake of simplicity.

depth. The three or four individual readings should not be used further unless averaged with other values as described below, since erratic high or low values may result from such things as striking a rock or lemming hole at a shallow depth. If a reading is obviously erratic the figure should be discarded and an additional penetration made nearby. To promote objectivity in selecting exact test locations the three or four penetrations should be arranged in a predetermined pattern around the test station. A square-grid system in which both test stations and test locations are equidistant is suggested for purposes of simplicity in testing and in analysis of data, since each reading will apply to an equal area and can be averaged without weighting.

If the surface is not uniform an effort should be made to test all significant surface conditions, and with a frequency roughly proportional to the areal frequency of the condition. For example, if the surface consists of vegetated hummocks separated by bare ground, the three test locations at each station should be arranged so that both the vegetated and the bare areas are tested, and in a proportion roughly equal to the proportion of the two conditions. In some areas the number of penetrations at each test station can be varied in such a way that all significant surface conditions will be tested with an appropriate frequency, otherwise the values should be appropriately weighted when they are averaged. The test data can be arranged in the notebook so that tests on similar surface conditions are in a column, facilitating analysis. In some areas of exceptionally uniform soil with little or no vegetation (e. g., unvegetated wind-deposited silt, dry sand such as the Centrum Sø Site, or deltaic clay flats such as the Brønlund Fjord airstrip) the soil strength may be so uniform that it is unnecessary to make more than one penetration at each test station. In some unvegetated arctic desert areas the soil conditions may be obviously so uniform over large areas that the test stations can be separated as widely as many hundreds of feet without loss of significant detail. However in vegetated areas the spacing of stations should generally not exceed 100 feet even for purposes of hasty reconnaissance.

Need for Statistical Analysis of Cone Index Data

The minimum soil strengths required to support a specific number of coverages by specific aircraft have been determined fairly accurately, and equally accurate methods have been developed for quickly determining whether a given point on the ground meets this minimum requirement. However the methods for quickly evaluating whether a large potential landing area meets the minimum requirement are far less accurate and the problem becomes a statistical one, both areally and seasonally, especially: (1) when it is necessary to evaluate landing areas that are blanketed by vegetation, where the most important factors affecting soil strength are not visible at the surface; (2) when it is necessary to evaluate remote landing areas that can be visited on only a few days during a single year; and (3) in evaluations by means of the aerial penetrometer. In a statistical analysis arbitrary decisions may have to be made as to the frequency, both areally and seasonally, with which lower-than-minimum soil strengths can be tolerated in a potential landing area. Decisions may also have to be made as to the maximum areal extent or longest duration of such conditions that can be tolerated. The fact that some incidence of substandard conditions can be tolerated on remote runways is evidenced by the fact that most operational runways in the Arctic have been closed or greatly shortened on occasion by various natural conditions 7/. Similarly, natural landing strips in inhospitable arctic areas such as North and East Greenland would be expected to be locally or infrequently made unsuitable by natural conditions. For example, the Brønlund Fjord airstrip in North Greenland is subject to occasional flooding during 1 month of the year, but during 10 or 11 months has a smooth, hard surface and an exceptionally high bearing strength capable of supporting the heaviest cargo aircraft. Economic considerations make it obvious that such sites should be evaluated, marked, and reported so that they can be utilized to their maximum capability when needed, such as in an emergency.

Methods of Interpretation of Cone Index Data

During Operation Groundhogs (1957-1959) cone index or aircraft index values were interpreted into terms of aircraft trafficability by means of graphs in Report No. 77, Air Force Surveys in Geophysics 8/. In that report, Figure 4 (p. 9) was used to correlate cone index values with CBR (California Bearing Ratio) values. Then the CBR values were related to aircraft trafficability by means of Figures 19 and 20 (p. 32-33). Since the curve of cone index vs. CBR on Figure 4 is based on an average of 18 different soils, its use is based on the assumption that these soils are sufficiently representative that the curve is generally applicable. It is recognized that its use is a shortcut to permit rapid evaluation of a runway site and that evaluations so derived are only an approximation of the actual conditions. If time permits in the future it would be preferable to follow one or more of the following procedures:

7/ For example, the runways at Thule AFB, Nord, and Mesters Vig have all been greatly shortened or made unusable on occasion by collapse of various sections, by permafrost problems, etc.

8/ C. E. Molineux, 1955, Remote determination of soil trafficability by the aerial penetrometer: Air Force Cambridge Research Center, Air Force Surveys in Geophysics No. 77, 46 p.

(1) measure CBR values directly in the field; (2) convert cone index values into CBR values by using the appropriate curves for each soil type in which the readings were obtained; or (3) relate cone index values directly to vehicle trafficability by procedures similar to those developed by Waterways Experiment Station 9/. These three alternative procedures are discussed further below:

(1) The direct measurement of CBR values requires heavy equipment and considerable time, and is therefore not well-suited to making detailed areal studies or reconnaissance investigations. However it would be desirable to make as many direct CBR measurements as possible on arctic soils, such as the measurements made in 1959 at Polaris Promontory, in order to determine the relation between CBR and cone index values on those soils and thereby to permit a more widespread and accurate use of the cone penetrometer, airfield penetrometer, and aerial penetrometer in the Arctic.

(2) The use of separate curves for each soil type in order to relate cone index to CBR values involves several complicating factors. The soil type may vary areally over the surface of a runway site, even in an unvegetated area of exceptionally uniform soil. For example, on the Brønlund Fjord airstrip both soil types CL and CL-ML are present at the surface. If the soil were covered by typical tundra vegetation it would be difficult or impossible to determine the areal distribution of such soil types. The presence of sand horizons within the clay soil at Brønlund Fjord illustrates another complication. Extreme variations in soil type within one foot of the ground surface will be found on many landing sites that are covered by a thin mantle of wind-deposited silt or fine sand, such as the Storelv Site. In addition, a mat of turf up to 6 inches thick covers many potential landing sites in the Arctic and further complicates the interpretation of cone index data.

(3) Procedures for evaluating soil trafficability similar to those developed by Waterways Experiment Station are thought to be best-suited to the type of evaluations conducted during Operation Groundhog. However there may be a need for further work to determine the vehicle cone indexes of various types of aircraft for varying numbers of coverages over a landing strip.

9/ These procedures require the measurement of cone index and remolding index of the soil, determination of rating cone index, and comparison of that value with the vehicle cone index for a particular vehicle. The procedures are well-suited to hasty field investigations, as described in a report by S. J. Knight, 1956, Trafficability of soils, a summary of trafficability studies through 1955: Waterways Experiment Station Technical Memorandum 3-240, Fourteenth Supplement, 93 p.

FIELD TESTS OF SOIL STRENGTH IN EAST GREENLAND

During August 1959 the strength of the soil was measured and recorded at 290 locations in East Greenland by means of a cone penetrometer designed and constructed by the Waterways Experiment Station, Corps of Engineers, U. S. Army. A total of about 850 penetrations were made with that instrument and the cone index (an index of shearing resistance of the soil) was recorded about 5500 times at 1-inch intervals from the surface down to the maximum possible depth of penetration or to a maximum depth of about 12 inches, whichever was shallower. About 210 of the locations were on potential runway sites or on test strips in which cone index was recorded at intervals along a centerline. Seven such strips were tested in sufficient detail so that the mean cone index values can be considered fairly reliable and can provide a basis for prediction of average and minimum soil strengths in similar areas that were not visited on the ground or that were not tested in detail with the soil penetrometer. The remaining 80 or more test locations were chiefly in the vicinity of potential runway sites, where test were made to quickly evaluate questionable areas, to round out areas of investigation, and to test soil strength under a wide variety of conditions for purposes of comparison.

SUMMARY OF CONE INDEX DATA FROM EAST GREENLAND

The average cone index readings for most test strips are summarized graphically in Fig. 9. These graphs are an indication of the average cone index values that can be expected in areas of similar soil conditions in East Greenland in midsummer. However, the minimum cone index that is likely to occur with a frequency of a few percent is also quite significant for evaluating areas as unprepared landing sites. An indication of this is obtained from frequency distribution curves such as that shown on Fig. 10. The minimum cone index values that are estimated to occur with frequencies of 10 percent and 2 percent on all test strips are summarized on Table 10.

INTERPRETATION OF CONE INDEX DATA FROM EAST GREENLAND

Strength of Wind-Deposited Silt and Fine Sand

Distribution

In general most areas in East Greenland that were investigated on the ground and that were found flat enough to be considered potential landing sites proved to be rather soft near the surface. The principal

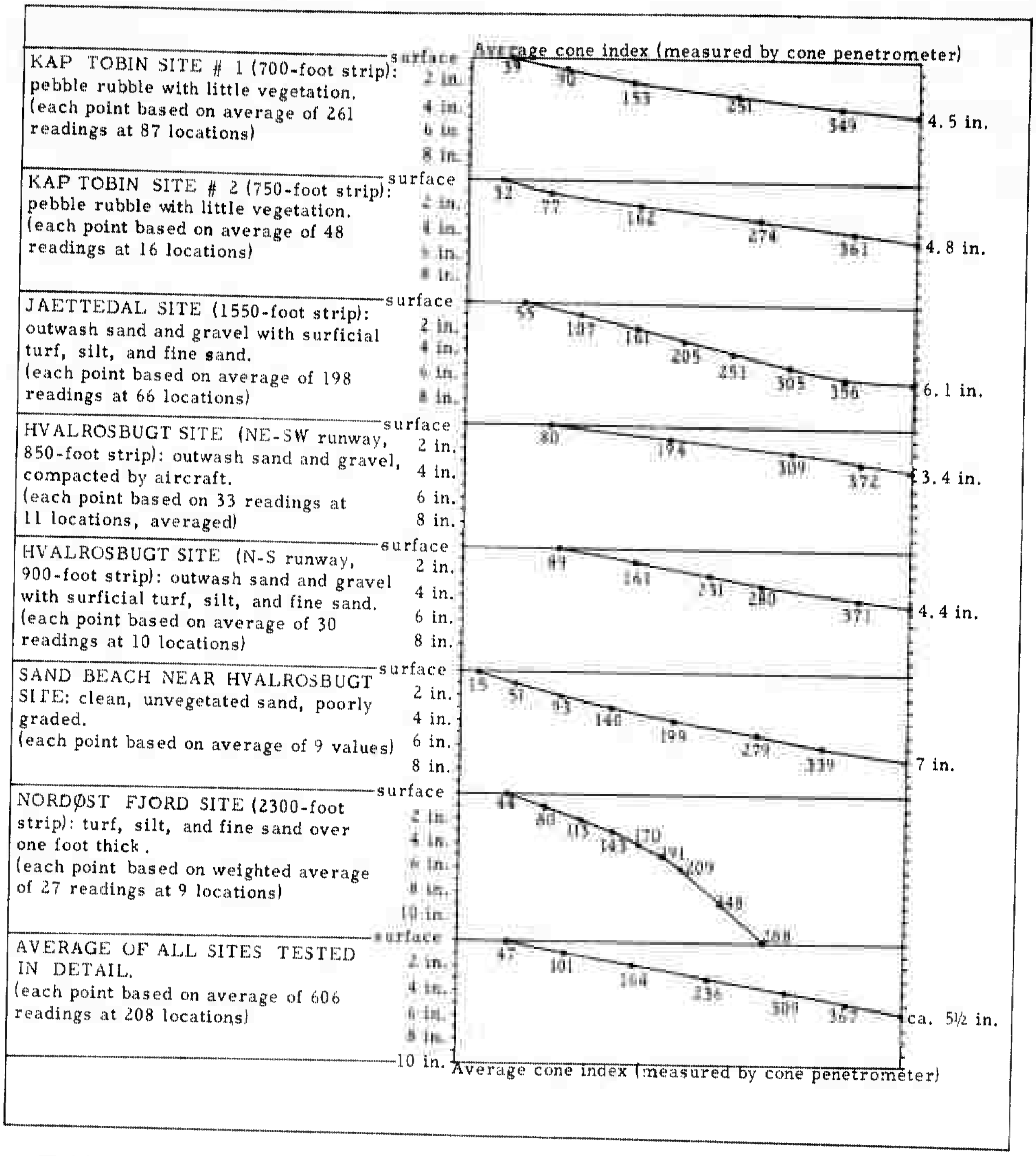

Figure 9. Summary of cone index readings on seven test strips in East Greenland.

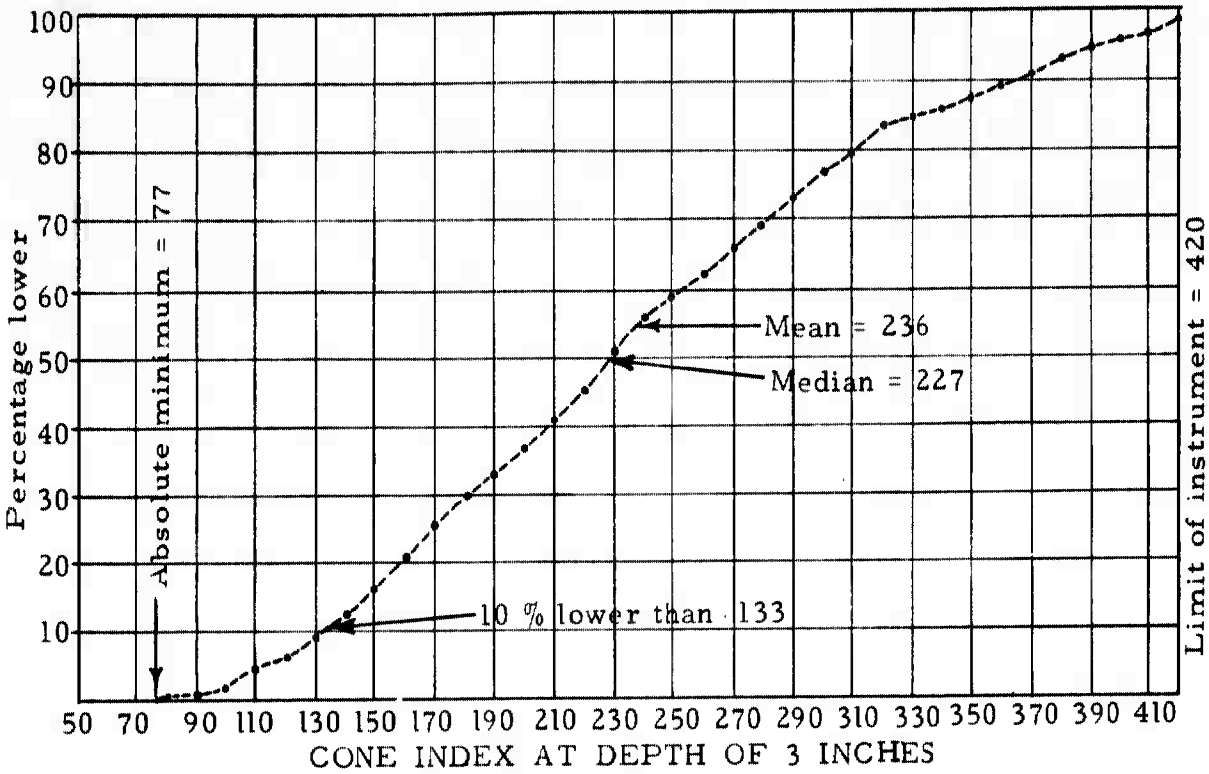

Figure 10. Cumulative frequency distribution of cone index values at a depth of 3 inches on unprepared landing sites and potential runway sites in East Greenland.

factor causing a low bearing strength in otherwise favorable areas was a mantle of wind-deposited silt and fine sand which covers most well-drained terraces that are above the level of seasonal flooding. This silty mantle averages well over 1 foot deep on the Nordøst Fjord Site and averages 1 foot deep on the Storelv Site. Numerous areas that would otherwise make excellent landing sites and that appeared favorable on aerial photographs were found unsuitable because of a thick silty mantle. A thinner mantle of silt that would not seriously hamper aircraft landings was found on many low stream terraces such as the Jaettedal Site, the Hvalrosbugt Site, the terrace immediately north of that site, and the low terraces in the Storelv area. It is expected that many other potential landing sites in East Greenland will have a similar silty mantle, ranging from a few inches to a few feet in thickness. This silty mantle would be the most critical factor for aircraft operations on some of the best natural landing sites in East Greenland. The Nordøst Fjord Site is the only area in which the silt mantle was sufficiently deep and uniform to give strength-test results that are not confused by the underlying subsoil. These tests provide a basis for predicting the strength of other silt-covered landing sites in East Greenland, including sites in the Storelv area, where cone penetrometer tests were made invalid by surficial freezing of the ground and by

Table 10. Summary of cone penetrometer data on seven test strips in East Greenland.
(mean, estimated 10-percentile, and estimated 2-percentile cone index values at various depths)

M: mean cone index values 10%: estimated 10-percentile cone index values 2%: estimated 2-percentile cone index values

Test strips	Soil conditions	Surface			1 in. deep			2 in. deep			3 in. deep			4 in. deep			5 in. deep			6 in. deep			7 in. deep			9 in. deep			1 ft. deep		
		M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%	M	10%	2%
Hvalrosbugt Site(NE-SW runway)	Outwash sand and gravel; compacted by aircraft	80	43	37	194	123	116	309	210	150	372	283	200	420	350	250	420	373	300	420	413	387	420	420	420	---	---	---	---	---	---
Hvalrosbugt Site(N-S runway)	Outwash sand and gravel; surficial turf, silt, fine sand	89	60	49	161	117	96	231	150	129	280	203	141	371	300	177	420	362	309	420	390	360	420	420	420	---	---	---	---	---	---
Kap Tobin Site #2	Pebble rubble with little vegetation	32	20	15	77	47	34	162	107	74	274	197	117	361	273	158	420	333	276	420	367	340	420	420	420	---	---	---	---	---	---
Kap Tobin Site #1	Pebble rubble with little vegetation	39	23	18	90	55	40	153	90	70	251	137	107	349	260	153	420	363	267	420	413	387	420	420	420	---	---	---	---	---	---
Jaettedal Site	Outwash sand and gravel; surficial turf, silt, fine sand	55	40	30	107	72	64	161	103	90	205	123	103	251	153	120	305	207	146	356	273	200	420		225	---	370	292	---	420	420
Sand beach near Hvalrosbugt Site	Clean, unvegetated sand, poorly graded	17	15	10	51	40	31	93	70	52	140	105	70	199	130	95	279	180	134	339	220	190	420		235	---	420	420	---	---	---
Nordøst Fjord Site	Turf, silt, and fine sand over 1 foot thick	44	33	24	80	50	40	113	63	55	143	93	70	170	123	85	191	145	100	209	167	115			130	248	208	150	288	213	175

Note: The values are considered useful in estimating the strength of untested areas in East Greenland having surface and soil conditions similar to the test strips. Mean values are considered useful in quickly comparing areas without requiring analysis of frequency distribution. Estimated 10-percentile values are a better indication of the softest areas of significant size that may be unavoidable on unimproved emergency landing strips, even those that have been carefully preselected and marked on the ground. Estimated 2-percentile values give some indication of the softest areas of significant size that might be encountered during emergency landings on unmarked areas.

a fall of wet snow in early September that saturated the ground surface. Therefore the data from the Nordøst Fjord Site, scanty though they are, will be analyzed in considerable detail as an indication of probable conditions at Storelv and other silt-covered sites that were not tested in detail with the cone penetrometer.

Effect of Vegetation Cover and Soil Hummocks

Areas covered by a silty mantle in East Greenland are commonly characterized by rounded soil hummocks 6 to 36 inches in diameter and 2 to 8 inches high. Where the hummocks are very prominent, as on the Nordøst Fjord Site, there is commonly bare ground in the narrow depressions between the hummocks. A comparison of penetrometer readings in the vegetated centers of hummocks with those in the bare ground between the hummocks is shown in Fig. 9. From the surface down to a depth of 2 inches beneath bare areas the cone index averages about 30 points higher (equivalent to CBR about 1 1/2) than at similar depths beneath vegetated areas. This is interpreted to be a result of the fact that the upper few inches of the hummocks are largely composed of living vegetation and dead organic matter, the strength of which cannot be adequately measured with a cone penetrometer. At depths of 3 to 4 inches below the surface the cone index is nearly equal in both areas. At depths of 5 or more inches beneath bare areas the cone index averages nearly 50 points lower (equivalent to about 2 CBR units) than at similar depths beneath the vegetated areas. Since vegetated hummocks are several inches higher than the intervening bare areas, the discrepancy in soil strength at any given level in the soil is commonly equivalent to more than 80 cone index units or more than 3 CBR units; i. e., the soil strength under vegetated hummocks is commonly 50 percent to 100 percent higher than that under the intervening bare areas.

Evaluation for Aircraft Landings

Landings on preselected and marked airstrips. Most areas found to be covered by a wind-deposited mantle were considered unsafe for aircraft landings because of the presence of soil hummocks. Therefore evaluations of this type of soil are confined to the single factor of soil strength assuming such factors as topography and microrelief are favorable. The following evaluations are based on the lowest recorded cone index value at each depth below the surface of the Nordøst Fjord Site. Since these values were recorded by a hasty reconnaissance party few readings were possible and these lowest recorded values can be considered only roughly indicative of the 10- to 20-percentile values that would result from a detailed survey of soil strength in the area.

At the surface of the Nordøst Fjord Site, and presumably of other sites covered by a wind-deposited mantle of silt and fine sand, the strength of the soil appears insufficient to support a single coverage by planes even as light as a Dornier (DO-27). At a depth of about 1 inch below the surface the strength is considered sufficient to support one coverage by a Dornier, and at a depth of 2 inches one coverage by an Otter (DHC-3). At a depth of 3 inches the strength is considered adequate to support one coverage by planes with wheel loads up to 15,000 lbs and with tire pressures up to 50 psi. At a depth of 4 inches the strength is considered adequate for one coverage by planes as heavy as a C-47 and at 5 inches for an unloaded C-124 or the equivalent (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure). A heavier plane than an unloaded C-124 should probably not attempt to make a landing on such a surface unless there was a possibility of improving the surface prior to takeoff.

Landings on unmarked areas. On unmarked areas, and in situations in which it is only possible to make a low-level aerial reconnaissance prior to landing, areas covered by a wind-deposited mantle of silt and fine sand are not considered safe for landings, even by planes as light as a Dornier (DO-27).

Strength of Deltaic Silt and Sand

Deltas at the mouths of many streams in East Greenland are composed largely of silt and sand with lenses and stringers of gravel. Many of the smoothest and flattest land areas, including many suitable sites for winter ski-landings on snow, are on material of this type. Delta areas that are subject to seasonal flooding during the melt season and areas that are subject to strong wind action are nearly bare of vegetation. Inactive areas that are raised slightly above the active part of the delta are generally covered by a thin blanket of turf. In many areas thin layers of wind-deposited silt and fine sand cover the surface, and probably most bare areas are subject to some wind-shifting of surface materials.

Soil strength was measured at a number of isolated spots on deltaic deposits in East Greenland, but no such areas were tested systematically and test results are not adequate to permit reliable comparisons between these and other areas. Test results on this type of deposit would be expected to be confused by the presence of wind-deposited silt or fine sand in some areas and by the removal of fine materials by the wind in other areas. In general most areas of deltaic silt and fine sand that were tested appeared to be at least as soft as the Nordøst Fjord Site, which is covered by a thick mantle of wind-deposited silt and fine sand. Since the two types of deposits commonly grade into each other near the surface of deltas it would be expected that the surficial soil strength of the two types of deposits would be closely comparable under similar vegetation and drainage conditions.

Evaluation for Aircraft Landings

On unvegetated, active parts of deltas it is estimated that the strength of the soil would generally be unsuitable for landings by planes, even as light as a Dornier (DO-27), unless the ground were frozen or snow-covered. On vegetated, inactive parts of deltas it is estimated that the soil may locally be sufficiently strong to permit one emergency landing and takeoff by a cargo plane as heavy as an unloaded C-124 with 50 psi tire pressure, provided that the landing is on a preselected and marked airstrip. Since safety factors would be near unity, it is emphasized that even vegetated portions of deltas should be used only in an emergency and then only for one coverage. Such areas that have not been investigated and marked on the ground are not recommended in any case.

Strength of Beach Sand

Sand beaches and bars are present at many locations in East Greenland, especially along shores and near the heads of bays. A dry sand bar and beach on the north shore of Hvalrosbugt was tested with the cone penetrometer in mid-August. These tests provide a rough basis for predicting the suitability of similar areas for landing light aircraft in East Greenland.

Evaluation for Aircraft Landings

The following evaluations are based on the lowest recorded cone index value at each depth below the surface. Since few readings were possible these lowest recorded values can be considered only roughly indicative of the 10-percentile values that would result from a detailed survey of soil strength in the area.

In the uppermost 1 1/2 inches of sand the strength of the soil appears insufficient to support a single coverage by planes, even as light as a Dornier (DO-27). At a depth of 2 inches below the surface the strength is considered sufficient to support one coverage by a Caribou (DHC-4). It is doubtful that such areas will be found long enough and smooth enough for planes larger than a Caribou (requiring runway at least 630 feet long for emergency landing with full load, zero wind, and flaps at 30°). However a site similar to the Hvalrosbugt beach would have adequate strength at a depth of 3 inches to support one coverage by planes with wheel loads up to 15,000 lbs and with tire pressures up to 50 psi. At a depth of 3 1/2 inches the strength would be considered adequate for one coverage by planes as heavy as a C-47 and at 4 1/2 inches for an unloaded C-124 or the equivalent (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure). No matter how long or smooth, such areas should probably not be used for emergency landings by planes heavier than an unloaded C-124.

Since safety factors are very small, it is emphasized that such areas should be used only in an emergency. Sand areas that have not been investigated and marked on the ground are not recommended in any case.

Strength of Outwash Gravel and Sand

Coarse deposits of glacial outwash form plains and terraces bordering many glacier-fed streams in East Greenland. Many of the best potential airstrips are located on this type of material. Shearing strength tests were made on such material at the Jaettedal and Hvalrosbugt airstrips near Scoresbysund and provide a basis for predicting the suitability of other similar areas for aircraft landings. Both of the tested areas were largely covered by a thin layer of vegetation and probably a small amount of wind-deposited material. These thin surface layers of soft material confuse the strength-test results to some extent, although most outwash deposits in East Greenland are probably covered by a similar soft layer. Where this soft surficial layer is thicker than the permissible depth of rutting by aircraft wheels the critical factors in evaluating suitability are probably the strength of the surficial mantle and the size of soil hummocks or other microrelief features on the surface. Where the strength of the surficial mantle is insufficient to support the aircraft the critical factor is the depth to a firm foundation of outwash gravel and sand.

Evaluation for Aircraft Landings

Landings on preselected and marked airstrips. The following evaluations are based on the 10-percentile cone index values at the Jaettedal Site, the softest area of outwash gravel and sand that was tested in East Greenland. It is assumed that in a detailed investigation of most potential sites on outwash deposits a runway could be located on which the softest areas of a size significant for aircraft operations would be no softer than the 10-percentile values recorded at the Jaettedal Site.

About one-half inch below the surface of the Jaettedal Site, and presumably of other sites on outwash gravel and sand, the strength of the soil is sufficient to support as least one coverage by light planes such as a Dornier (DO-27). At a depth of about 1 inch the strength is considered adequate to support at least one coverage by planes at least as heavy as a Caribou (DHC-4). At a depth of 2 inches the strength is considered sufficient to support one coverage by planes with wheel loads at least as great as 15,000 lbs and with tire pressures of at least 50 psi. At a depth of 4 inches the strength is considered adequate for at least one coverage by an unloaded C-124 or the equivalent (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure), and at a depth of 5 inches a fully loaded C-124 (gross weight 210,000 lbs or wheel load about 53,000 lbs with 60 psi tire pressure). A plane more exacting on a runway surface than a fully loaded C-124 should probably not attempt to make a landing on surfaces with a strength similar to that of the Jaettedal Site. However better sites, such as the Hvalrosbugt Site, could probably be located on many outwash areas. It is emphasized that the above evaluations are for landings on a preselected and marked airstrip.

Landings on unmarked areas. The following evaluations are for emergency landings on unmarked areas of glacial outwash in situations in which it is only possible to make a low-level aerial reconnaissance prior to landing. If such unmarked areas are covered by a layer of turf they are not considered safe for landings, even by planes as light as a Dornier (DO-27), since there may be a surficial layer of wind-deposited silt or fine sand that is deeper than the permissible depth of rutting by aircraft wheels. If such areas are sufficiently bare of vegetation that the outwash gravel and sand can be seen to lie near the surface over the entire landing area, an estimate of the minimum probable strength can be based on the softer parts of the Jaettedal Site. The following evaluations are based on the approximate 2-percentile cone index values at that site, which is the softest area of outwash gravel and sand that was tested in East Greenland.

About 1 inch below the surface the strength of the soil is sufficient to support at least one coverage by a Dornier (DO-27), and at a depth of 2 inches by planes with wheel loads up to 10,000 lbs and tire pressures up to 50 psi. At a depth of 3 inches the strength is adequate for one coverage by planes with wheel loads up to 15,000 lbs and tire pressures up to 50 psi, and at 4 inches one coverage by a C-47. At a depth of 5 inches the strength would probably be sufficient to support at least one coverage by an unloaded C-124 or the equivalent (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure). A plane heavier than an unloaded C-124 should probably not attempt to make an emergency landing on unmarked areas of outwash gravel and sand.

Strength of Angular Gravel-Sized Rubble

Angular rubble probably covers a large percentage of terrain in East Greenland, but very few potential landing sites, because of the presence of such obstructions as cobbles, boulders, bedrock outcrops, soil polygons, solifluction ridges, etc. There are probably a few potential sites for short airstrips for light aircraft on such terrain, but probably few if any sites for natural strips longer than 1000 feet. In any case, the use of such areas for landings would require careful ground reconnaissance and marking since they are characterized by abrupt variations in strength within short horizontal distances. Unless they are considerably better than the sites investigated in 1959 such strips should be used only in an emergency.

Evaluation for Aircraft Landings

The following evaluations of soil strength are based on two test strips near Kap Tobin. Evaluations are based on the 10-percentile cone index values on the softer of these two strips (Kap Tobin Site #1). It is assumed that in a detailed investigation of most potential landing areas on rubble a runway could be located on which the softest areas of a size significant for aircraft operations would be no softer than the 10-percentile values recorded at the Kap Tobin Site.

About 1 inch below the surface of the Kap Tobin Site, and presumably of other carefully selected sites on angular rubble, the strength of the soil is sufficient to support one coverage by light planes such as a Dornier (DO-27). At a depth of about 2 inches the strength is considered adequate to support at least one coverage by planes as heavy as a Caribou (DHC-4). It is doubtful that such areas will be found long enough and smooth enough for planes larger than a Caribou (requiring runway at least 630 feet long for emergency landing with full load, zero wind, and flaps at 30°). However a site similar to the Kap Tobin Site would have adequate strength at a depth of 3 inches to support one coverage by planes with wheel loads up to 15,000 lbs and with tire pressures up to 50 psi. At a depth of 4 inches the strength would be considered adequate for one coverage by planes as heavy as an unloaded C-124 or the equivalent (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure). It is emphasized that rubble areas that have not been investigated and marked on the ground are not recommended for landings in any case.

CONCLUSIONS

It is concluded that an extremely wide range of surficial deposits in East Greenland are sufficiently strong to support at least one emergency landing and takeoff by cargo planes as heavy as an unloaded C-124 (gross weight up to 145,000 lbs or wheel load up to about 36,000 lbs with 50 psi tire pressure), provided that the landing is on a preselected and marked airstrip. However unmarked areas can rarely be considered safe for even a single landing by a very light aircraft. Conclusions for several types of surficial deposits that were tested are as follows:

1. A wind-deposited mantle of silt and fine sand covered by a few inches of typical tundra vegetation is estimated to be sufficiently strong

to permit one emergency landing and takeoff by a cargo plane as heavy as an unloaded C-124, provided that the landing is on a preselected and marked airstrip. But it is warned that most of these areas were covered by soil hummocks that made them unsafe for landings.

2. Deltaic silt and fine sand in unvegetated, active parts of deltas are estimated to be unsuitable for landings, even by planes as light as a Dornier (DO-27), unless the ground were frozen or snow-covered. Vegetated, inactive parts of deltas may locally be sufficiently strong to permit one emergency landing and takeoff by a cargo plane on a preselected and marked airstrip.

3. Sand beaches and bars are estimated to be locally suitable for one coverage by a Caribou (DHC-4) on a preselected strip. Probably few of such areas are long enough and smooth enough for larger aircraft, although the soil strength is estimated to be adequate for some cargo planes.

4. Outwash gravel and sand is estimated to permit local landings by planes as heavy as a fully loaded C-124 on a preselected and marked airstrip. Many such areas are estimated to be sufficiently strong to permit an emergency landing by an unloaded C-124 on unmarked areas after low-level aerial reconnaissance to locate the most favorable orientation.

5. Areas of angular rubble are estimated to be locally suitable for one coverage by a Caribou (DHC-4) on a preselected strip; probably few of such areas are long enough and smooth enough for larger aircraft.

APPENDIX II. RECONNAISSANCE OF EMERGENCY WATER SUPPLIES IN EAST GREENLAND

by

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APPENDIX II. RECONNAISSANCE OF EMERGENCY WATER SUPPLIES IN EAST GREENLAND

INTRODUCTION

This appendix describes a reconnaissance study of potable water supplies in the ice-free part of East Greenland. Sites visited were in the vicinity of Kulusuk, Scoresbysund, Syd Kap, Mesters Vig, and Myggbukta (Fig. 11). Locations of sampling points were determined as accurately as possible on United States Army Map Service maps having a scale of 1/250,000 (Table 11).

The reconnaissance of water supplies was made in connection with an expedition to East Greenland sponsored by the Royal Greenland Trade Department and the Air Force Cambridge Research Center. The general object of the expedition was to evaluate several possible emergency landing sites which had been located through photogeologic studies of the United States Geological Survey. Transportation was by the icebreaker USS ATKA and by helicopter based on the ship.

The original plan of operation anticipated a study of water supplies from at least 15 separate areas together with field analyses of about 100 water samples. Sea-ice conditions along the coast, however, were unusually severe so that transportation difficulties made it impossible to complete more than one-third of the original plan. Field time was limited to only about 14 days, of which 6 days were of reduced value because of a ground cover of new snow (Photograph 16). Some field time was conserved by making most of the "field" analyses of water on board the USS ATKA (Tables 11 and 12, Samples 1 through 31). Lack of time, nevertheless, eliminated the possibility of anything but a rough estimate of spring and stream discharges.

The Kulusuk area, from which Samples 1 through 16 were collected, has a spectacular alpine topography carved out of resistant granitic gneiss. All watersheds of lakes and streams which were sampled are steep and small; none had an area of more than 4 square miles. Heavy winter snows were evidenced by the fact that the ground retained about a 10 percent snow cover in the first part of August. Most samples collected represented melted snow with a maximum distance of subsurface flow of only 500 feet.

The topography in the Scoresbysund region is more subdued and the drainage basins generally larger than at Kulusuk. Only two large drainage basins, however, were sampled in this region (Table 11, Samples 21 and 28). The amount of snow present at the time of

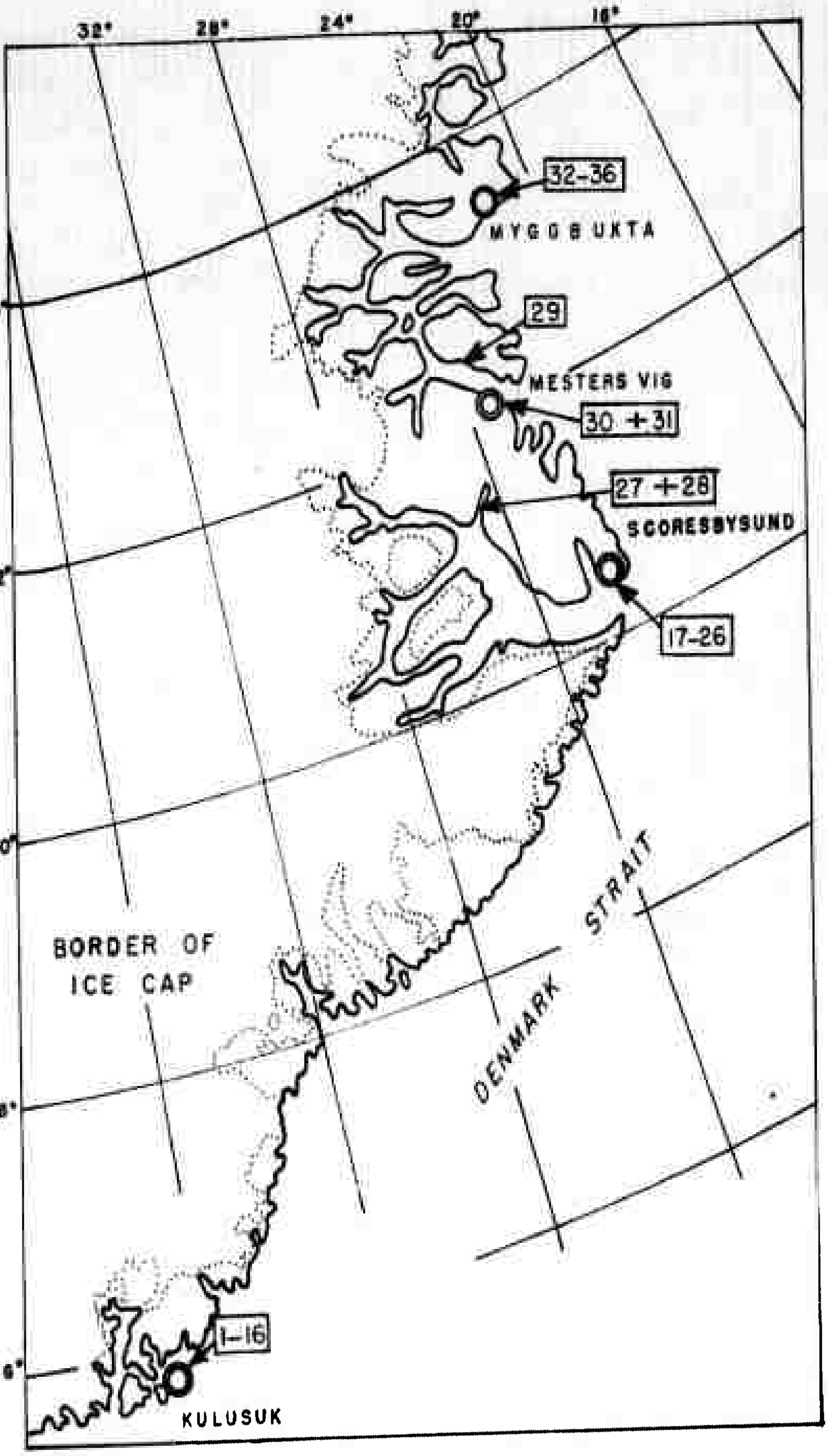


Figure 11. Index map showing location of water samples.

Table 11. Description of water samples from East Greenland.

Sample Number	Source of Sample	Date 1959	Bedrock	Latitude	Longitude
1	Shallow lake, 5 acres, with outlet.	Aug. 6	Biotite, quartz, feldspar gneiss	65°40'20"	37°08'45"
2	Water seeping out of talus.	6	Biotite, quartz, feldspar gneiss	65 40 20	37 08 40
3	Stagnant pond with vegetation along edges.	6	Biotite, quartz, feldspar gneiss	65 39 35	37 11 15
4	Spring from shallow tundra soil.	6	Biotite, quartz, feldspar gneiss	65 39 15	37 11 20
5	Spring from shallow inorganic soil.	6	Garnet, biotite, quartz, feldspar gneiss	65 39 10	37 11 20
6	Kulusuk Bay.	6	----	65 38 50	37 11 40
7	Cirque lake with outlet.	9	Biotite, quartz, feldspar gneiss	65 38 17	37 09 45
8	Stagnant pond in rocky tundra.	9	Garnet, biotite, quartz, feldspar gneiss	65 38 50	37 11 40
9	Water seeping from rocky tundra.	9	Garnet, biotite, quartz, feldspar gneiss	65 38 50	37 11 40
10	Lake, 4 acres, about 10 ft deep, with outlet.	10	Garnet, biotite, quartz, feldspar gneiss	65 39 22	37 11 50
11	Small pool in bare rock, 1/2 evaporated.	10	Garnet, biotite, quartz, feldspar gneiss	65 39 15	37 11 25
12	Stream from melting snow, about 5 cfs.	6	Garnet, biotite, quartz, feldspar gneiss	65 39 00	37 11 20
13	Spring in beach gravel.	10	Garnet, biotite, quartz, feldspar gneiss	65 39 06	37 11 20

Table 11. (continued)

Sample Number	Source of Sample	Date 1959	Bedrock	Latitude	Longitude
14	Meltwater, edge of snowbank.	Aug. 10	Garnet, biotite, quartz, feldspar gneiss	65°38'43"	37°11'38"
15	Old snow.	10	Garnet, biotite, quartz, feldspar gneiss	65 38 43	37 11 38
16	Lake near Kulusuk, village water supply, outlet.	11	Gneiss	65 34 48	37 12 12
17	Lake, Kap Tobin water supply, outlet.	17	Gneiss and basalt dike	70 24 30	21 50 10
18	Hot spring, about 10 gpm.	17	Gneiss and basalt dikes, boulder rubble at surface	70 24 30	21 48 10
19	Lagoon back of beach ridge.	18	Biotite, quartz, feldspar gneiss	70 25 50	21 50 00
20	Spring from rubble field, about 20 gpm.	18	Biotite, quartz, feldspar gneiss	70 25 50	21 50 00
21	Stream in Jaettedal.	21	Gneiss	70 30 50	22 05 30
22	Small pond, no outlet.	21	Gneiss and glacial outwash	70 30 50	22 05 30
23	Snow from top of sea ice.	22	----	70 10 --	21 40 --
24	Small melt pond top of sea ice.	22	----	70 10 --	21 40 --
25	Spring, patterned ground.	17	Gneiss	70 25 50	21 50 00
26	Stagnant pond, no vegetation.	18	Gneiss	70 25 50	21 50 00

Table 11. (continued)

Sample Number	Source of Sample	Date 1959	Bedrock	Latitude	Longitude
27	Small stream, water supply for part of Syd Kap.	Aug. 19	Gneiss	71°18'50"	25°06'10"
28	Sjaellandselv, about 80 cfs.	20	Triassic and Jurassic sandstone and shale	70 38 15	23 57 30
29	Karupelv, about 30 cfs.	28	Carboniferous, Triassic, and Jurassic sandstone and shale	72 35 10	23 49 00
30	Shallow well in outwash gravel, Mesters Vig mine supply.	29	Carboniferous sediments, mostly sandstone	72 13 --	24 06 --
31	Small stream, drains Mesters Vig dock area.	29	Basalt and Carboniferous sediments	72 15 --	23 52 --
32	Fresh snow, melted in aluminum kettle	Sept. 4	----	73 40 20	22 04 --
33	Creek, about 20 gpm.	4	Basalt and granite	73 40 20	22 04 --
34	Storelv, about 15 cfs.	4	Devonian and Carboniferous sediments, basalt, and granite	73 40 20	22 04 --
35	Pond, no outlet.	4	Glacial outwash	73 40 15	22 03 --
36	Pond, no outlet.	4	Glacial outwash	73 40 15	22 02 --

Key to abbreviations: ft, feet; gpm, gallons per minute; and cfs, cubic feet per second.

sampling was almost negligible in all drainage basins sampled except that of Sample 28 which contained two small glaciers and several small perennial snow fields.

The topography in the vicinity of Mesters Vig is mountainous with moderate-sized drainage basins carved out of Paleozoic and Mesozoic sediments. Samples which were collected in this area (Table 11, Samples 29, 30, and 31) are all diluted somewhat by meltwater flowing directly from small snow fields and glaciers.

Samples 32 through 36 are from a relatively flat valley north of Myggbukta. These samples were collected after about 8 inches of snow had fallen; consequently their chemical quality must be affected somewhat through direct dilution by newly melted snow. The amount of melting, however, was not great prior to sampling.

Members of the scientific party included Helge Larsen, Ministry of Greenland; Ole Skaerbo, Royal Greenland Trade Department; Joseph H. Hartshorn, George E. Stoertz, and Allan N. Kover, United States Geological Survey; and Lowell R. Satin and Stanley N. Davis, Arctic Institute of North America. The cooperation and help of the members of the party made the collection and field analyses of the water samples possible. In addition Mr. Skaerbo collected two of the samples and gave valuable information concerning the water supplies of many Greenland communities not visited by the expedition. John H. Feth of the United States Geological Survey kindly arranged for the laboratory analyses which were made at Menlo Park, California (Table 13). To the above individuals and to many others of the USS ATKA and of the mining camp at Mesters Vig who helped in innumerable ways, the author expresses his deep appreciation.

SOURCES OF FRESH WATER

Very few people have ever experienced difficulty in finding fresh water in East Greenland in quantities sufficient for the needs of survival. Streams, ice, lakes, and areas of water seepage are abundant in the summer, and snow is always available in the winter. The driest area visited was Jameson Land, west of Scoresbysund, but even here during the summer small streams and ponds are no more than 4 miles apart. In general the time and energy necessary to thaw snow and ice are so large that considerable effort is justified in locating sources of unfrozen water for the winter months. The problem of winter supply is considered in this report. Field work was completed during the summer, however, so comments concerning possible winter supplies are based on information supplied by local residents and inferences drawn from hydrologic and geologic evidence.

Table 12. Field analyses of water samples from East Greenland.

Sample Number	pH	Chemical Table -- Parts Per Million											Temp. °F
		SiO_2	H_2S	Fe	Ca	Mg	CO_3	HCO_3	SO_4	Cl	Total Hardness	Ca Hardness	
1	8.2	tr.	0.0	0.0	2	0.5	0.0	7	0	2	7	5	52
2	8.1	tr.	0.0	0.0	2	1.7	0.0	11	0	4	12	5	53
3	7.6	1.0	---	tr.	1	0.5	0.0	12	0	3	4	2	62
4	7.3	1.5	---	0.0	3	1.2	0.0	12	0	4	12	7	42
5	7.3	0.5	---	0.0	3	1.0	0.0	10	5	8	12	8	42
6	8.0	tr.	0.0	0.0	---	---	0.0	---	200	10,000+	---	---	39
7	7.6	tr.	---	0.0	1	1.0	0.0	10	0	3	7	3	37
8	6.1	0.5	---	0.0	1	0.4	0.0	11	3	1	3	1.5	43
9	7.4	tr.	---	0.0	0.6	0.6	0.0	9	0	3	4	1.5	43
10	7.2	tr.	---	0.0	1	1.0	0.C	10	5	4	7	3	53
11	7.5	0.5	---	0.0	1	2	0.0	11	5	5	10	2	54
12	7.6	1.5	---	tr.	2	1.2	0.0	17	5	3	10	5	36
13	7.3	tr.	---	0.0	2	6	0.0	12	10	89	29	6	39
14	7.5	tr.	---	0.0	0.4	0.4	0.0	7	0	1	2.5	1	34
15	7.1	0	---	0.0	tr.	0.2	0.0	6	0	0.5	1.0	tr.	32
16	6.8	0.5	---	0.0	---	---	0.0	12	---	11	---	---	--

Table 12. (continued)

Sample Number	pH	Chemical Table -- Parts Per Million											Temp. °F
		SiO_2	H_2S	Fe	Ca	Mg	CO_3	HCO_3	SO_4	Cl	Total Hardness	Ca Hardness	
17	7.1	1.5	tr.	0.0	56	5	0.0	12	50	143	162	140	39
18	6.4	30	1.5	0.0	1240	0	0.0	27	650	6100	3120	3140	180±
19	8.1	tr.	---	0.0	2	1.0	0.0	5	5	6	8	4	50
20	7.4	2.5	---	tr.	4	4	0.0	10	8	15	24	9	47
21	7.6	1.5	---	0.0	10	2	0.0	24	10	1	34	24	47
22	8.1	2.5	---	0.0	8	1.5	0.0	20	3	0.5	26	20	51
23	7.6	tr.	---	0.0	0.6	0.4	0.0	7	28	4	3	1.5	32
24	7.4	tr.	---	0.0	2	10	0.0	5	20	36	46	6	32
25	7.6	2.0	---	tr.	2	1.0	0.0	10	3	0.5	8	4	38
26	7.9	2.5	---	tr.	2	1.0	0.0	13	5	1	8	4	48
27	7.6	4.0	---	tr.	3	2	0.0	11	10	0.5	16	8	--
28	4.8	8	---	0.4	34	18	0.0	5	170	6	156	84	--
29	7.7	2.5	---	0.0	38	10	0.0	64	55	4	136	94	--
30	7.9	4.0	---	0.0	25	3	0.0	69	15	4	76	62	--
31	7.9	5.0	---	0.0	26	11	0.0	58	15	18	82	64	38
32	8.0	---	---	0.0	---	---	---	---	---	12	17	---	32

Table 12. (continued)

Sample Number	pH	Chemical Table -- Parts Per Million											Temp. °F
		SiO_2	H_2S	Fe	Ca	Mg	CO_3	HCO_3	SO_4	Cl	Total Hardness	Ca Hardness	
33	8.0	---	---	0.0	---	---	---	---	---	12	170±	---	34
34	8.1	---	---	0.0	---	---	---	---	---	12	85±	---	32
35	8.4	---	---	0.0	---	---	---	---	---	12±	200±	---	34
36	8.3	---	---	0.0	---	---	---	---	---	12±	220±	---	33
	0.2	1.0	0.5	0.6	2.0	1.0	4.0	4.0	8.0	4.0	4.0	4.0	1.0
	Predicted accuracy, except for Samples 18, 32, 33, 34, 35, and 36.												
	---	0.2	0.2	0.1	0.2	0.1	0.2	0.5	2.0	0.3	0.5	0.5	--
	Smallest quantity detected.												
	---	1	---	---	---	---	---	21	4	9	9	4	--
	Standard deviation from U. S. G. S. Samples 12, 20, 29, 30, and 31.												

Table 13. Laboratory analyses of water samples from East Greenland
U. S. Geological Survey; Menlo Park, Calif.; A. S. Van Denburgh, Analyst

Sample Number	pH	Chemical Table -- Parts Per Million														Specific Conduct. Micromhos at 25°C
		SiO_2	Al	Fe	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	Hardness as $CaCO_3$	Dissol. Solids Calcul'd	
12	6.2	2.2	0.02	0.01	1.0	0.4	1.3	0.2	1.3	3.1	1.7	0.0	0.2	4.3	11	17
18	6.9	67	0.39	0.00	1260	25	2060	54	16	233	5240	3.4	0.7	3250	8950	14,400
20	6.7	2.8	0.06	0.02	3.7	0.4	19	1.2	5.0	5.4	29	0.3	0.2	11	65	131
29	7.3	2.4	0.09	0.00	34	8.8	4.5	0.7	90	52	0.5	0.1	0.2	122	148	265
30	7.7	2.7	0.04	0.00	24	3.0	2.2	0.8	84	9.1	0.2	0.0	0.2	72	84	161
31	7.3	3.1	0.07	0.01	25	4.0	3.8	1.4	90	12	3.6	0.1	1.1	80	98	187
32	6.0	0.2	0.06	0.02	0.9	0.2	0.42	0.1	4.0	0.7	0.6	0.0	0.2	3.0	5.4	10
33	8.1	5.8	0.07	0.00	44	8.5	1.5	0.4	177	0.2	0.9	0.2	0.1	145	149	273
34	7.5	1.6	0.08	0.00	22	3.1	1.0	0.6	75	4.0	0.4	0.4	0.2	68	70	139
35	7.6	9.8	0.06	0.00	58	10	2.8	1.3	223	0.0	4.2	0.5	0.4	189	197	352

Snow

Three samples of snow were tested (Table 12, Samples 15, 23, and 32). As would be expected, the chemical quality is excellent. This fact, together with its availability during most of the year, makes snow one of the most widely used emergency sources of water.

Sea Ice

When sea ice first forms, brine is concentrated in inclusions, and the ice has a salinity commonly as low as one-fifth the salinity of the original sea water (Assur, 1958). If the sea ice undergoes partial melting, the brine inclusions above the ocean surface will drain. Old polar ice can, by successive cycles of partial thawing and refreezing, become quite fresh in upper layers (Sverdrup, Johnson, and Fleming, 1942, p. 216-219).

One sample of granular ice and one sample of pond water were taken from the surface of sea ice near Scoresbysund (Table 12, Samples 23 and 24). The chloride content is so low that the ice and water are most likely derived from old snow rather than from frozen sea water that has been purified through freezing and partial thawing.

Ample fresh water for emergency use can be obtained from melt ponds on top of sea ice during summer months. This source is, however, largely frozen from the middle of September to the last of June.

Glacial Ice

The largest volume of potable water in East Greenland is in the form of glacial ice which is within a few miles of any point in the areas visited with the exception of southern Jameson Land. Glacial ice, in the form of icebergs, is found along the coast and in all the major fjords. Samples were not taken of glacial ice. Four analyses were made, however, of stream water derived in part from small glaciers (Table 12, Samples 21, 29, 30, and 34). This information, together with the known nature of precipitation which nourishes the glaciers, indicates that glacial ice in this region should be exceptionally pure. Owing to the inconveniences of obtaining large amounts of water directly from glaciers and icebergs, this source will be only of minor importance for ice-free areas.

Lakes

The most reliable sources of water in East Greenland are from lakes that are too deep to freeze completely during the winter. Pumping of lake water can continue through winter months provided distribution facilities are protected against freezing.

The greatest disadvantage of a lake supply is its susceptibility to pollution. For example, the small lake which furnishes water for the weather and radio station at Kap Tobin (Table 11, Sample 17) has large amounts of paper, dog feces, tin cans, boards, and animal bones submerged or floating in the water. The surface area that drains into the lake has a number of houses with the usual litter common to arctic habitations. Despite this, however, Dr. Nielsen, area medical officer, reported that there were no known illnesses in Kap Tobin which could be traced to water-born contamination. There is, nevertheless, a potential danger of transmitting pathogenic organisms through this and other lake supplies unless care is taken to protect watersheds.

Shallow ponds are abundant in all of the regions visited except in the highly mountainous areas and in parts of Jameson Land. Larger lakes which may remain unfrozen at depth are not as common, but they appear to be within 20 miles of almost all points on the ice-free land. Although saline lakes have been reported from northern Greenland (Stoertz and Needleman, 1957) and Antarctica (Péwé, and Llano, 1959), precipitation appears sufficient to maintain fresh water in lakes within the area studied.

Streams

Streams are an obvious source of fresh water during the summer; although in late August and early September the contribution from snow melt is small and the streams are mostly flowing with a small fraction of their early-summer discharges. For example, the channel of the Storelv which discharges into Moskusoksefjord in the Myggbukta region (Photograph 16) is about 400 feet wide and 4 to 5 feet deep. Lack of vegetation in the channel suggests that all the channel gravels are reworked annually by running water. If a cross section of 1000 to 1500 square feet and a mean velocity of 3 to 7 feet per second are assumed, a maximum discharge of several thousand cubic feet per second is indicated. The discharge of this stream was estimated to be only 15 cubic feet per second (cfs) on 4 September 1959. Similar apparent contrasts in maximum and late-summer discharges were noted in all the streams visited, even though many of the streams, including Storelv, are fed in part by glacial melt water.

Flowing streams are within 1 or 2 miles of any point within the areas studied and are, therefore, excellent sources of water during the summer. All streams sampled had potable water. The only undesirable aspects were a moderately high hardness in Samples 28, 29, 33, and 34 and an exceptionally low pH in Sample 28.

It is doubtful if any of the streams visited remain unfrozen during the entire winter. Streams with a discharge of less than 1.0 cfs are probably frozen before the middle of October. A small stream with a discharge of about 0.1 cfs (Table 11, Sample 33) was almost completely frozen by 6 September 1959, which was within one week of the time the first ice formed.

Ground Water

The difficulty of transporting heavy equipment and the presence of permafrost have discouraged the development of ground-water resources in East Greenland. Deepwater wells will probably not be drilled in the near future in this region except in conjunction with mineral exploration and development.

Ground-water discharges at the surface in springs and as diffuse seepage along the lower part of talus slopes, stream banks, and shorelines of lakes and fjords. Most of this water is circulating at shallow depths and probably freezes during the winter. Of the springs visited, only hot springs near Scoresbysund (Table 11, Sample 18) are known to flow throughout the year. Unfortunately the hot-spring water is not potable due to large amounts of calcium, sodium, chloride, and hydrogen sulfide. The water is, however, a potential source of heat for the settlement of Kap Tobin, provided the cost of pipes and insulation is not too large.

The mining camp at Mesters Vig is supplied throughout the year with water from a shallow pit in recent glacial outwash (Table 11, Sample 30). The water pumped in the summer probably represents stream water which has percolated only a few hundred feet through the gravel. In the winter the water must be drawn from storage from a large body of unsaturated material in the bottom of the valley. It is interesting to note that permafrost extends to a depth of about 300 feet in the mine which is on an adjacent valley side.

Three factors probably contribute to the absence of permafrost in the valley at Mesters Vig. First, winter snow settles in the valley and insulates the ground against the winter heat loss. Second, stream water transports heat to the valley during the summer. Third, the flow of earth heat is greatest in valleys because of the distortion of heat flow by surface topography. For these reasons, development of ground water should be successful in other deep mountain valleys which have a favorable exposure to the sun and an appreciable thickness of permeable alluvium or outwash gravel. Other possible locations to explore for perennial aquifers are near large rivers and along the shores of lakes and fjords (Cederstrom, Johnston, and Subitzky, 1953).

WATER QUALITY

Analytical Techniques

Three different types of water analyses are included in Tables 12 and 13. The largest number of analyses (Table 12, Samples 1 through 31) are "field" analyses made by the author while on board the USS ATKA. Five analyses (Table 12, Samples 32 through 36) were made by the author on shore north of Myggbukta. Ten analyses were made by A. S. Van Denburgh of the United States Geological Survey in Menlo Park, California. The expected accuracy of the analyses varies from only a rough approximation in the field analyses made on shore to the highest order of precision in the laboratory analyses.

In the field, chloride, bicarbonate, sulfate, total hardness, and calcium hardness were determined by standard titrating procedures using 50 ml samples and colorimetric endpoints (American Public Health Assoc. and American Water Works Assoc., 1955). Iron, hydrogen sulfide, and silica were determined by colorimetric comparator kits marketed by the Hach Chemical Company, Ames, Iowa. Determination of pH was with a battery-operated pH meter. Hardness and chloride were determined on shore by drop-counting titration; that is, the volume of titrating solution was estimated by counting the number of drops used. All samples were collected in one-quart polyethylene bottles. Duplicate samples which were collected for laboratory analyses were sealed at the time of collection.

The smallest quantities of various dissolved constituents which were detectable in the field analyses are listed at the bottom of Table 12. Although a small trace of certain ions could be detected, analytical techniques were not accurate enough to measure actual quantities until concentrations were quite large. Expected accuracy of field determinations are also listed at the end of Table 12 and are based only on a consideration of the accuracy with which volumes can be measured and color changes estimated.

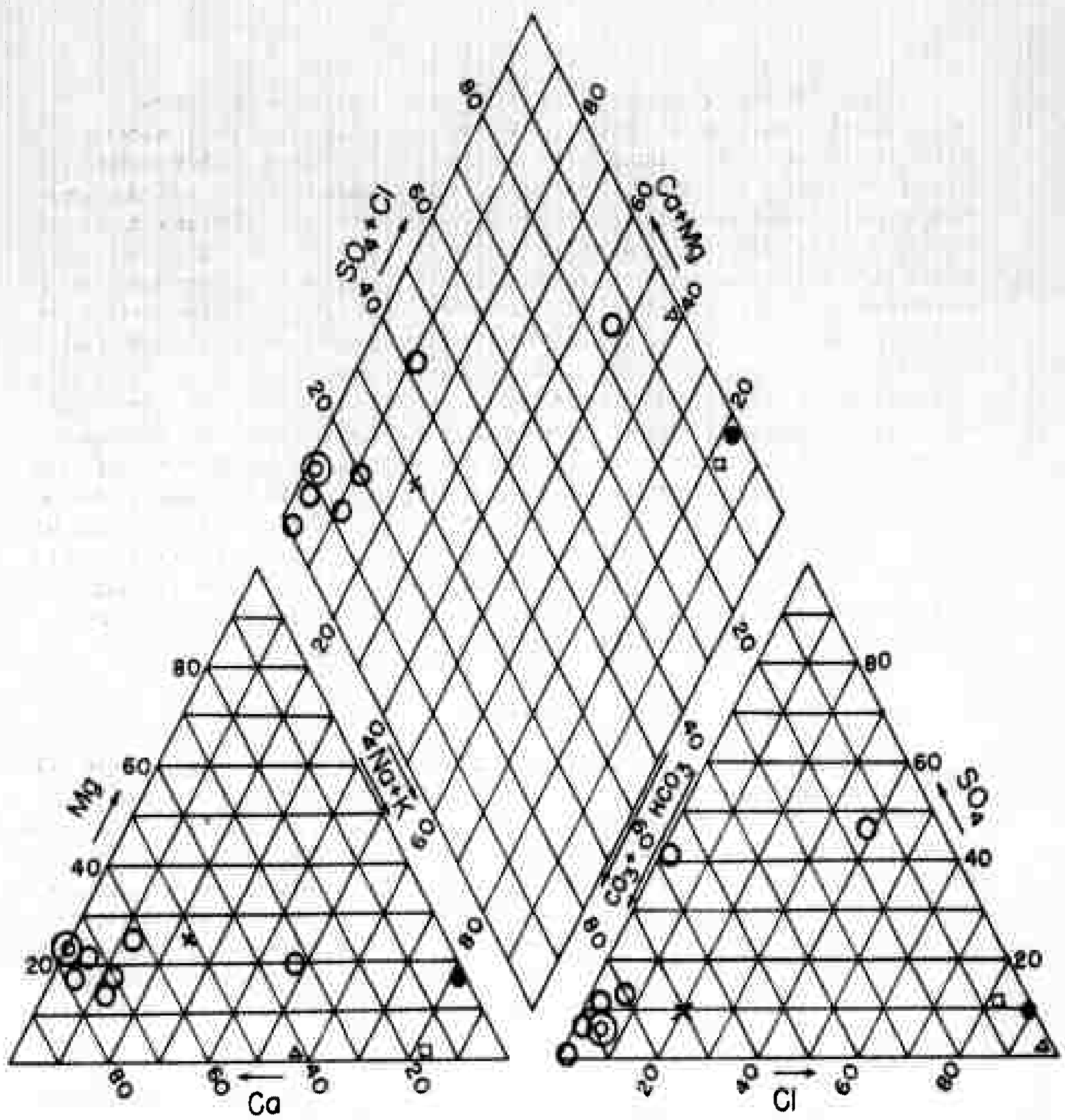
Some idea of the accuracy of field analyses can be gained by comparing them with the laboratory analyses. Standard deviations from laboratory results for five samples are listed at the bottom of Table 12. Samples 32 through 35 were not included in the comparison because the field analyses were only by drop-counting methods. Sample 18 was not included in the comparison because the analysis was made on a solution diluted with 20 parts of distilled water to one part of the sample. Errors in field determinations can be explained mostly by the unfavorable working environment. Possible airborne contamination which was circulated by the ship's ventilation system included ocean salt, detergent dust from the ship's laundry, and various powdered products from the galley. In addition, lighting was poor, and the ship's motion probably affected some volumetric readings.

All field determinations, except those for bicarbonate and pH, are considered satisfactory. Large errors in bicarbonate values can be explained by contamination and by poor determinations of colorimetric endpoints. The variations of pH appear much larger than normal pH adjustments between the time of sampling and the time of laboratory analyses. Biological activity during the 100 days of storage may account for some of the differences, particularly in samples having a low bicarbonate content. All field determinations were made in conjunction with instrumental checks with buffers having pH values of 4.0, 7.0, and 9.0. Field errors of more than 0.4 are, therefore, considered unlikely.

Despite the approximate nature of the field analyses, they were valuable in determining the general properties of the water encountered in East Greenland. All water sampled except sea water and hot-spring water (Table 12, Samples 6 and 18) was found to be potable. Most of the water is very pure and of excellent chemical quality for drinking. The field analyses also demonstrated that most of the samples were of calcium-sodium-bicarbonate water. The laboratory analyses, nevertheless, are necessary before ratios of various constituents can be calculated with confidence (Fig. 12) and generalizations concerning the abundance of many of the ions can be made.

Silica

Hutchinson (1957, p. 791) and Lovering (1959, p. 792) have suggested that surface water from tropical regions contains significantly more silica than surface water in temperate regions. Major factors controlling the supply of silica to streams and shallow ground water appear to be mineralogical composition of soils and rocks, temperature, biological activity, and time (Krauskopf, 1956; Lovering, 1959). It was anticipated that, because of low temperatures and sparse vegetation, water from an arctic environment would contain considerably less silica than comparable water from temperate regions. This appears indeed to be true if the data of this report are inspected casually. Silica values of less than 1.5 ppm (parts per million) are confined, however, to water which has had a minimum amount of contact time with rock or soil. Water from small ponds which receive abundant snow melt, water which has seeped only a short distance through soil or talus, and water from small streams are included in this low silica group. More silica is found in water from larger streams and ponds that receive slow percolation through widespread soils (Table 13, Sample 35). These facts suggest that differences of silica concentrations between arctic and temperate regions may be largely a function of runoff rates rather than differences in climate and vegetation. Obvious exceptions to this generalization are thermal waters such as those near Scoresbysund (Table 13, Sample 18) that contain large concentrations of silica which can be attributed to the high temperature of the water.



KEY TO SYMBOLS:

O Stream; Samples 12, 29, 30, 31, 33, and 34.

● Sea water (Sverdrup, Johnson, and Fleming, 1942, p. 176).

△ Hot spring; Sample 18.

□ Cold spring; Sample 20.

X Snow; Sample 32.

◎ Pond; Sample 35.

Figure 12. Water-analysis diagram of samples listed in Table 11.

A preliminary search of published water analyses was made to test the conclusions made from the Greenland analyses. Only waters having a low chloride content were used for comparison. This restriction is necessary to eliminate streams fed by connate water and streams that contain water concentrated by evapo-transpiration. Several hundred analyses were studied. The silica values in Tables 12 and 13 are mostly lower than those studied; nevertheless the difference is not striking and is certainly much less than would be inferred from data given by Hutchinson (1957, Table 112, p. 791). It is concluded from the comparisons that (1) surface water from the Arctic contains lower concentrations of silica than in temperate and tropical regions, (2) however, this difference in many areas is a function of rate of runoff rather than of temperature and vegetation, and (3) a careful study of such variables as bedrock lithology, soil types, runoff characteristics, and rainfall chemistry is necessary before significant interregional comparisons of the silica content of water can be made. In short, the opinion that climate and vegetation are highly important factors controlling silica concentrations in surface water remains an attractive hypothesis, but present evidence is not sufficient to convince those having normal scientific skepticism.

Cations

Dominant cations in waters tested were calcium and sodium with only secondary amounts of magnesium (Fig. 12). Seven out of the 10 samples contained more than 50 percent calcium. The calcium appears to be derived from the weathering of sedimentary rocks. One sample (Table 13, Sample 20) contained more than 80 percent sodium. Its similarity to the composition of sea water suggests contamination by ocean spray, inasmuch as it was collected within 300 feet of the shoreline. The total dissolved solids of this sample is less than 1/600th of the concentration of sea water. Two samples (Table 13, Samples 12 and 18) have intermediate amounts of calcium and magnesium.

The hot-spring water (Table 13, Sample 18) is the only sample which appears to have had its cation composition drastically affected by processes other than recycling oceanic salts, surface weathering, and solution of rocks at depth. The unusually low concentration of magnesium is probably related to some hydrothermal activity such as the subsurface formation of talc or dolomite. Several other hot springs are in the same area, but were not visited. Pedersen (1929) sampled three of the springs, all of which had compositions similar to that given in this report.

The total concentration of cations in most of the surface water is comparable to concentrations found in waters from areas of rapid runoff in temperate and tropical areas. One might speculate that chemical weathering in arctic regions is more active than is commonly believed. Wisconsin glaciation and modern processes of mass movement have exposed fresh rock which gives the impression of slow chemical weathering in most of arctic North America. Studies of runoff and water chemistry which are related to drainage basin size are needed in order to investigate actual rates of chemical weathering in arctic regions.

Anions

The amount and proportions of bicarbonate, sulfate, and chloride shown in Fig. 12 can be explained mostly by the solution of rock and soil materials and salts of marine origin. Marine salts appear most important in Samples 18 and 20 and rock and soil materials appear most important in Samples 29, 30, 33, 34, 35 (Table 13). The character of the water is further modified by anion exchange, biological activity, evaporation, and precipitation. No clear evidence for the relative importance of the various modifying factors can be given. The striking lack of sulfate in water from a shallow pond (Table 13, Sample 3; Photograph 17) may indicate that sulfate reducing bacteria are active in an extreme arctic environment. The pond is underlain by permafrost, so sulfate reduction, if present, is active within a few feet of the surface.

Photograph 17. Pond on outwash terrace near Storelv, the site of Water Sample 35. View west-northwest from a point about 1/2 mile WNW of the Storelv campsite. Date: 5 September 1959.

Summary of Quality in Relation to Use

The precipitation in East Greenland appears sufficient to maintain active surface or subsurface discharge from lakes and ponds thus keeping the chemical quality excellent for most uses. In areas sampled, acids and gases associated with the decay of organic material were not apparent. Water from small ponds within deposits of organic debris were colorless and odorless although algae coatings on rocks and organic silt in the bottoms of ponds gave the impression of highly colored water.

The only waters which were objectionable due to poor chemical quality were ocean water at Kulusuk because of high salinity (Sample 6), hot-spring water from Kap Tobin because of high salinity and hydrogen sulfide (Sample 18), and river water from Jameson Land because of low pH (Sample 28). The river water, however, is probably potable.

CONCLUSIONS

1. Snowfields, glaciers, lakes, streams, and springs generally contain water of excellent chemical quality in East Greenland.

2. Although concentrations of total dissolved solids are generally low, chemical weathering must be quite active during the short melt season.

3. Silica concentrations appear to be slightly lower in water from East Greenland than in water from the United States. The contrast may be due to differences in runoff rates rather than differences in temperature and vegetation.

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Thirty-three specific landing sites were investigated in the ice-free land area of East Greenland between Scoresby Sund and Loch Fyne. Eight of these are considered suitable for emergency landings in summer by heavy cargo planes, and several more for light cargo planes. Several sites were investigated for the Royal Greenland Trade Department in the Scoresbysund - Kap Tobin area. A 1550-ft airstrip was located on a gravel terrace in the Jaettedal, eight miles northwest of Kap Tobin, and a short strip requiring some construction work was located near Kap Tobin. An 11,500-ft airstrip was tentatively laid out on a gravel terrace at Storelv, near Moskusoksefjord. Utilization of (over)

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UNCLASSIFIED

I. Landing fields - Greenland

I. J. H. Hartshorn
II. G. E. Stoertz
III. A. E. Kover
IV. S. N. Davis

UNCLASSIFIED

AD

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AD

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Reconnaissance observations verify the presence of abundant emergency sources of fresh water in East Greenland; analyses of 36 samples indicate water of good to excellent chemical quality.

UNCLASSIFIED

AD

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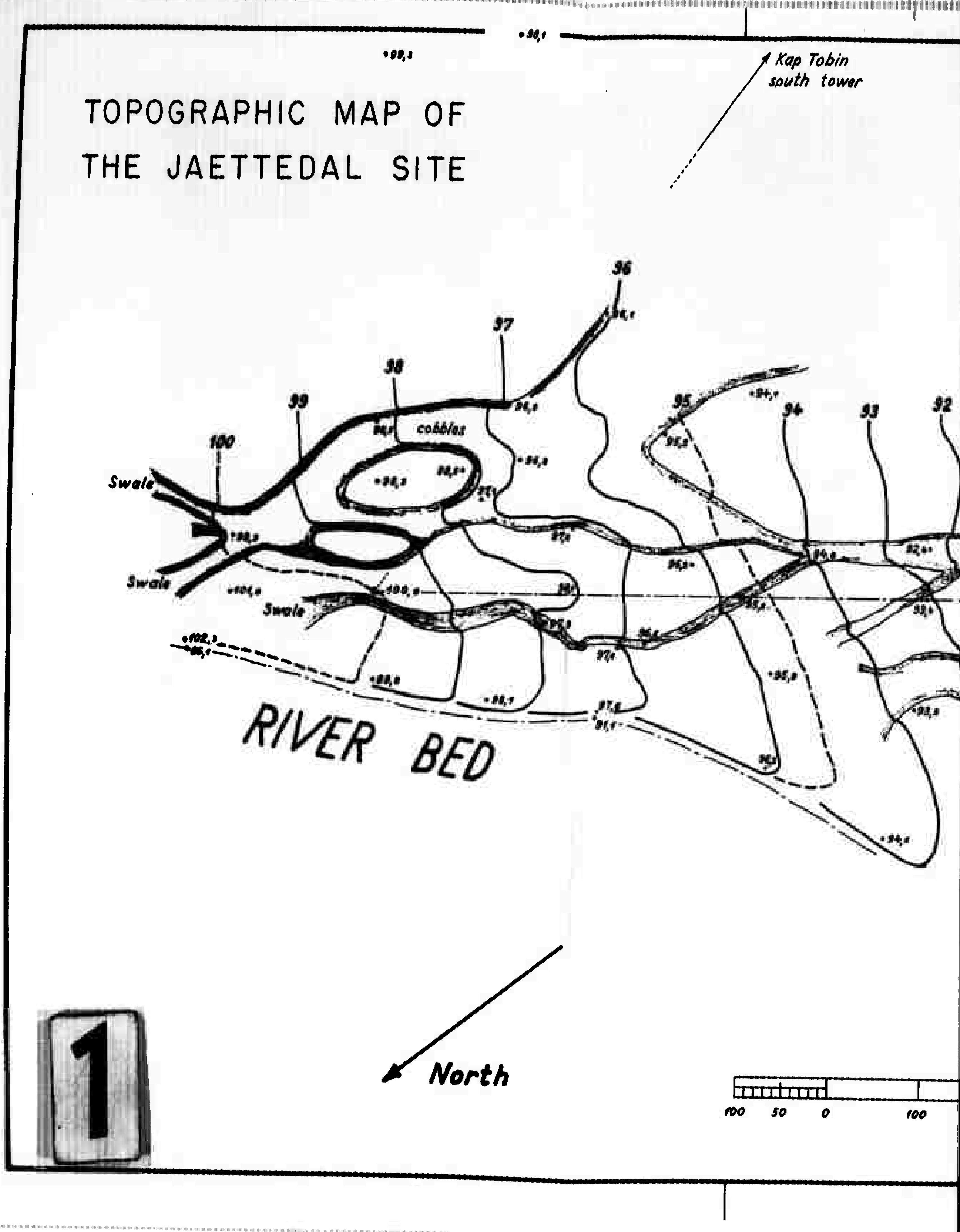
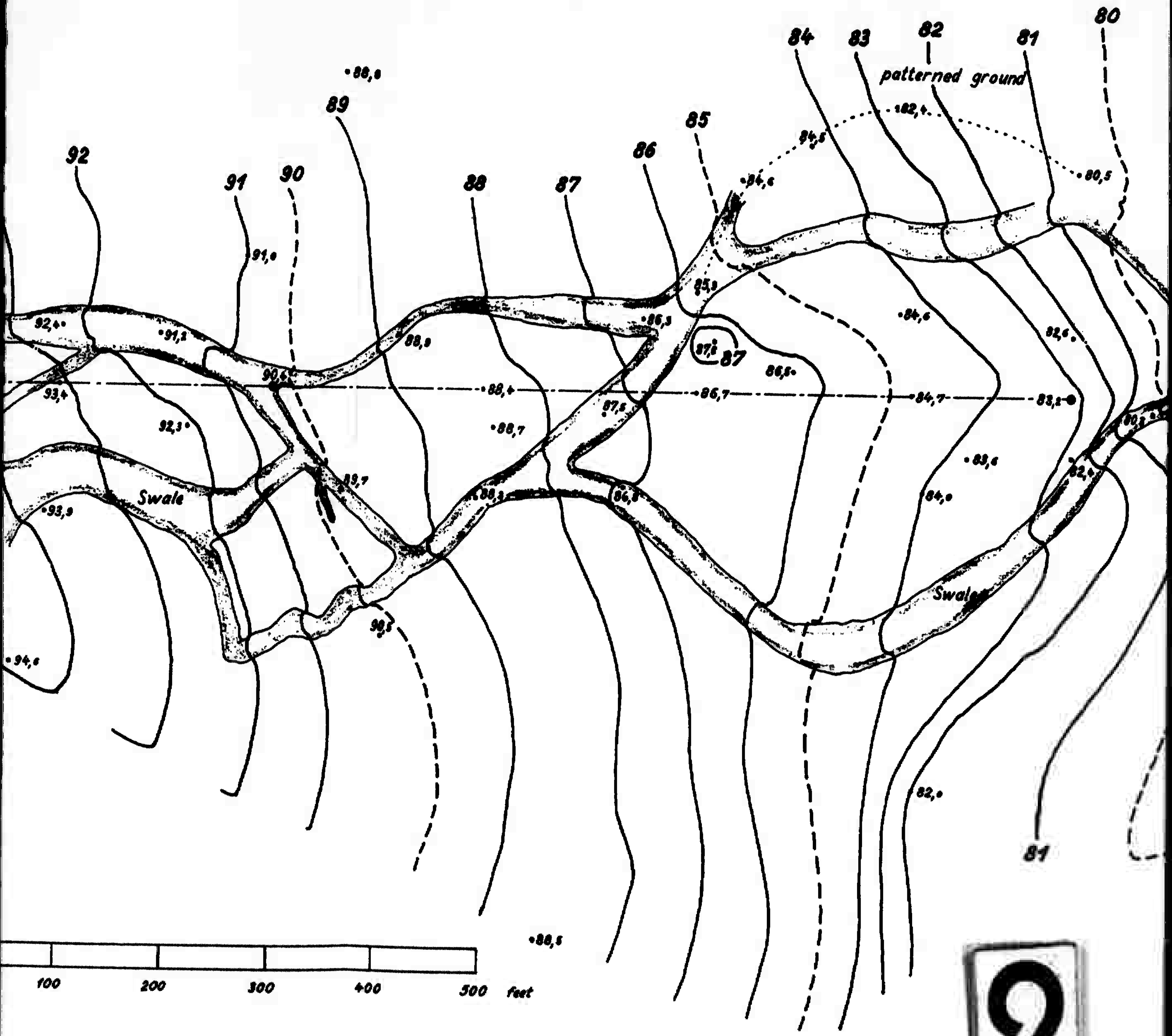
UNCLASSIFIED

UNCLASSIFIED



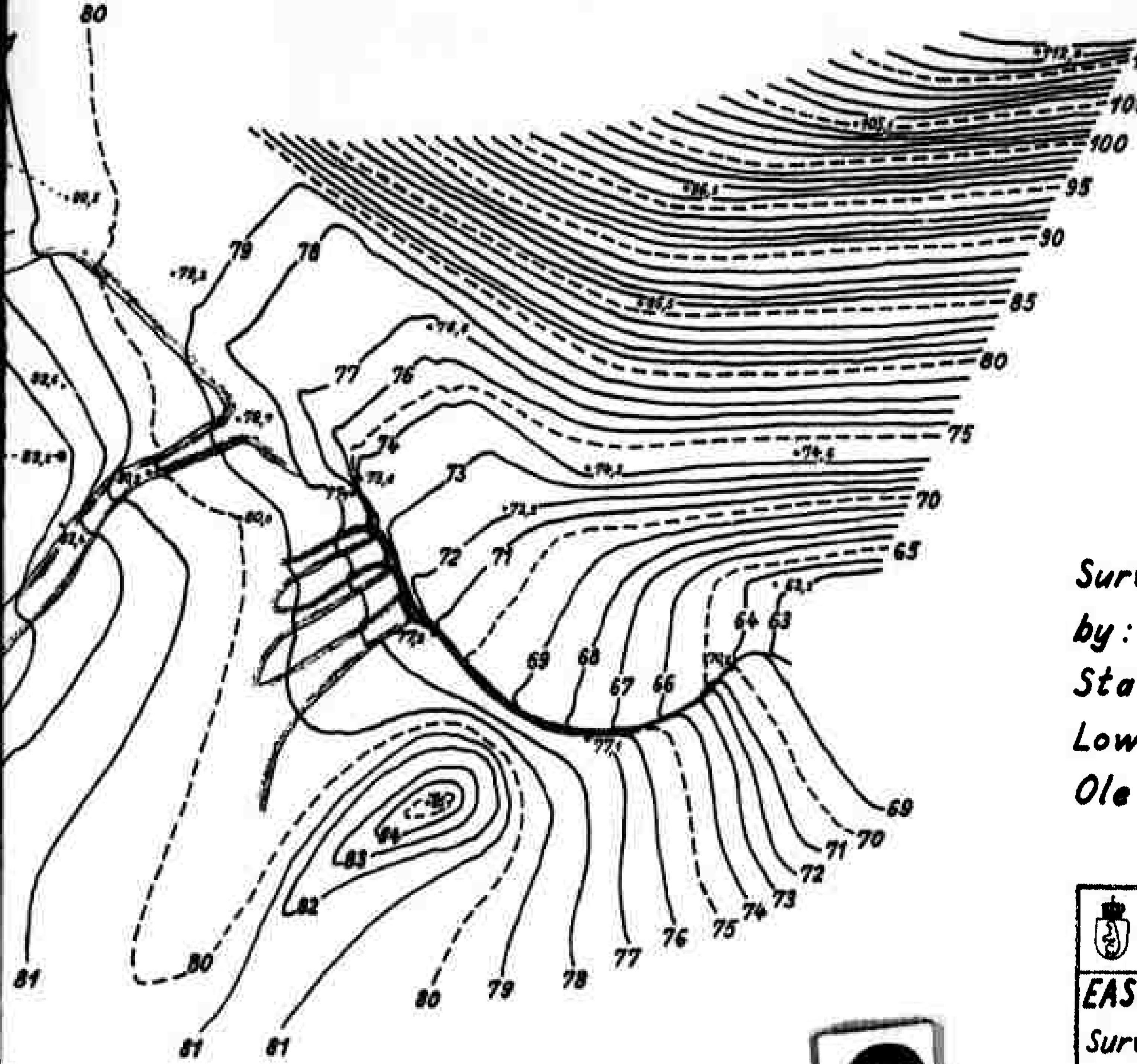
TOPOGRAPHIC MAP OF
THE JAETTEDAL SITE
Kap Tobin
south tower
100
99
98
97
96
95
94
93
92
cobbles
Swale
Swale
Swale
RIVER BED
North
100
50
0
100
1



80
81
82
83
84
85
86
87
88
89
90
91
92
81
87
patterned ground
Swale
Swale
100
200
300
400
500
feet

2

All levels are
referring to an
level of Origin
100,0 feet.



Surveyed 21 a
by:
Stanley N. D
Lowell R. Sa
Ole Skærbo

MINISTERIET

EASTGREENLAND

Survey of Jætt
approx 70°31'N, 2

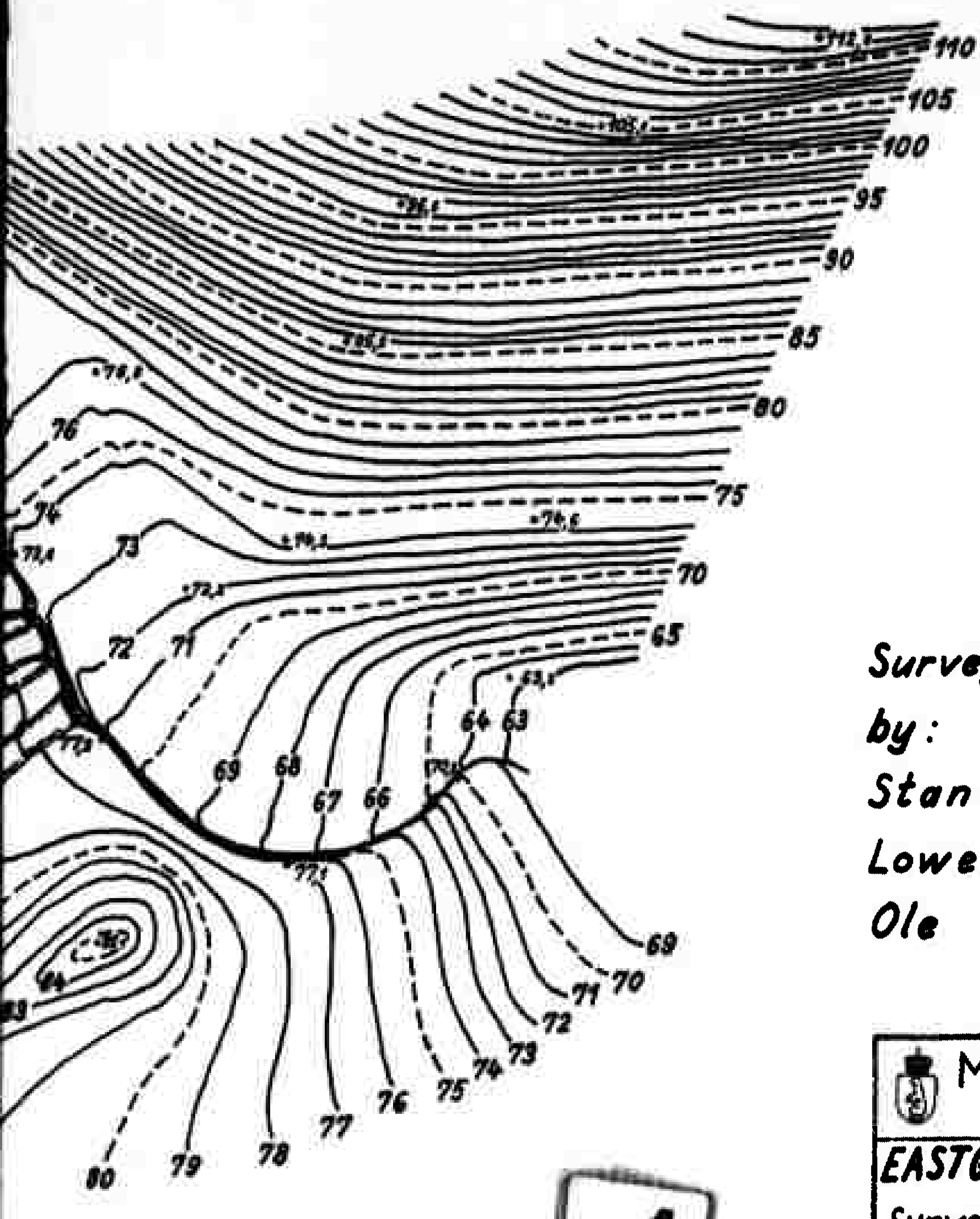
Opmålt: 21 aug

Tegnet: Oct. 1

SIGN.:

NR. 180

All levels are in feet referring to an estimated level of Origin to be 100,0 feet.



Surveyed 21 august 1959
by:
Stanley N. Davis
Lowell R. Satin
Ole Skærbo

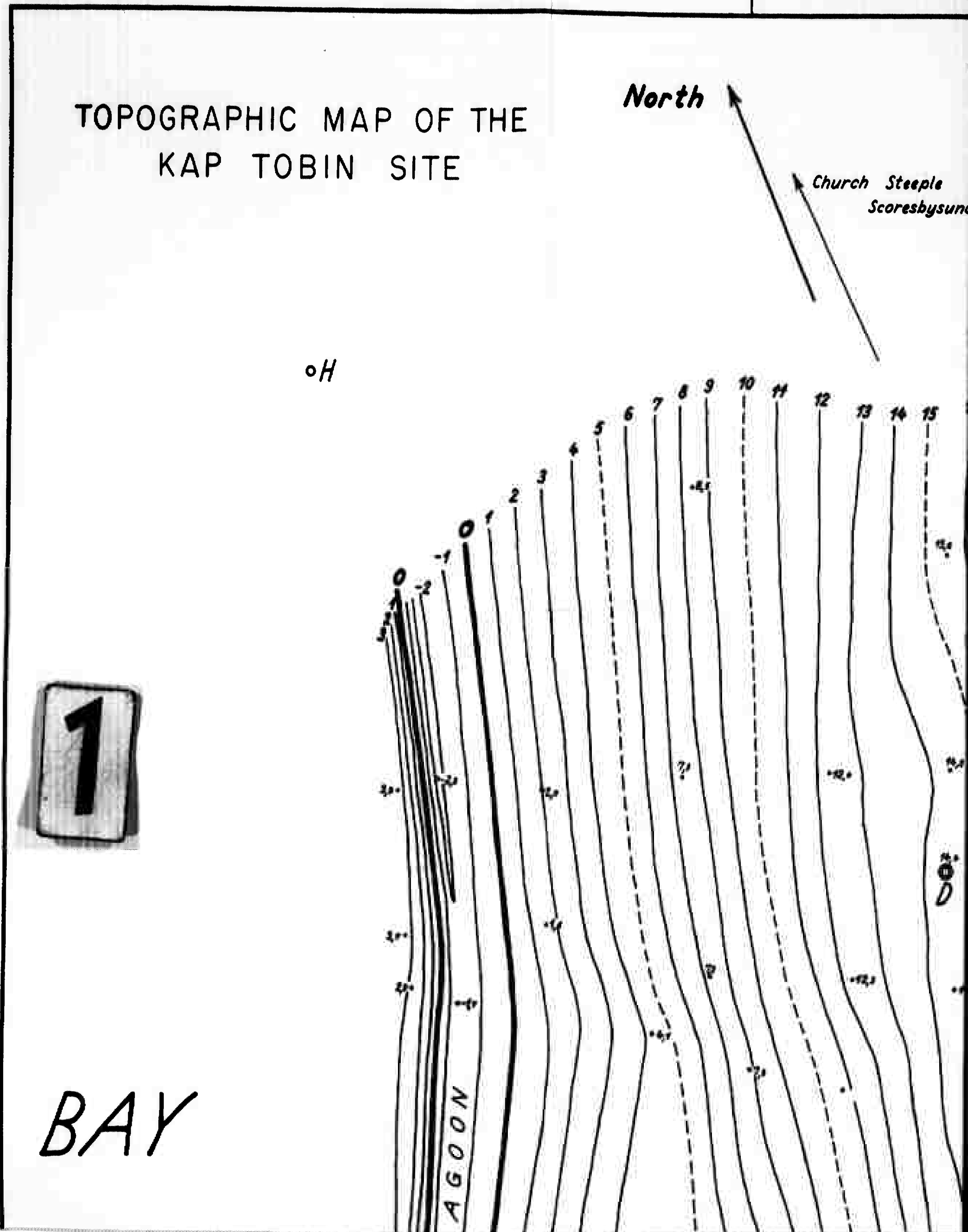
MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

EASTGREENLAND SCORESBYSUND

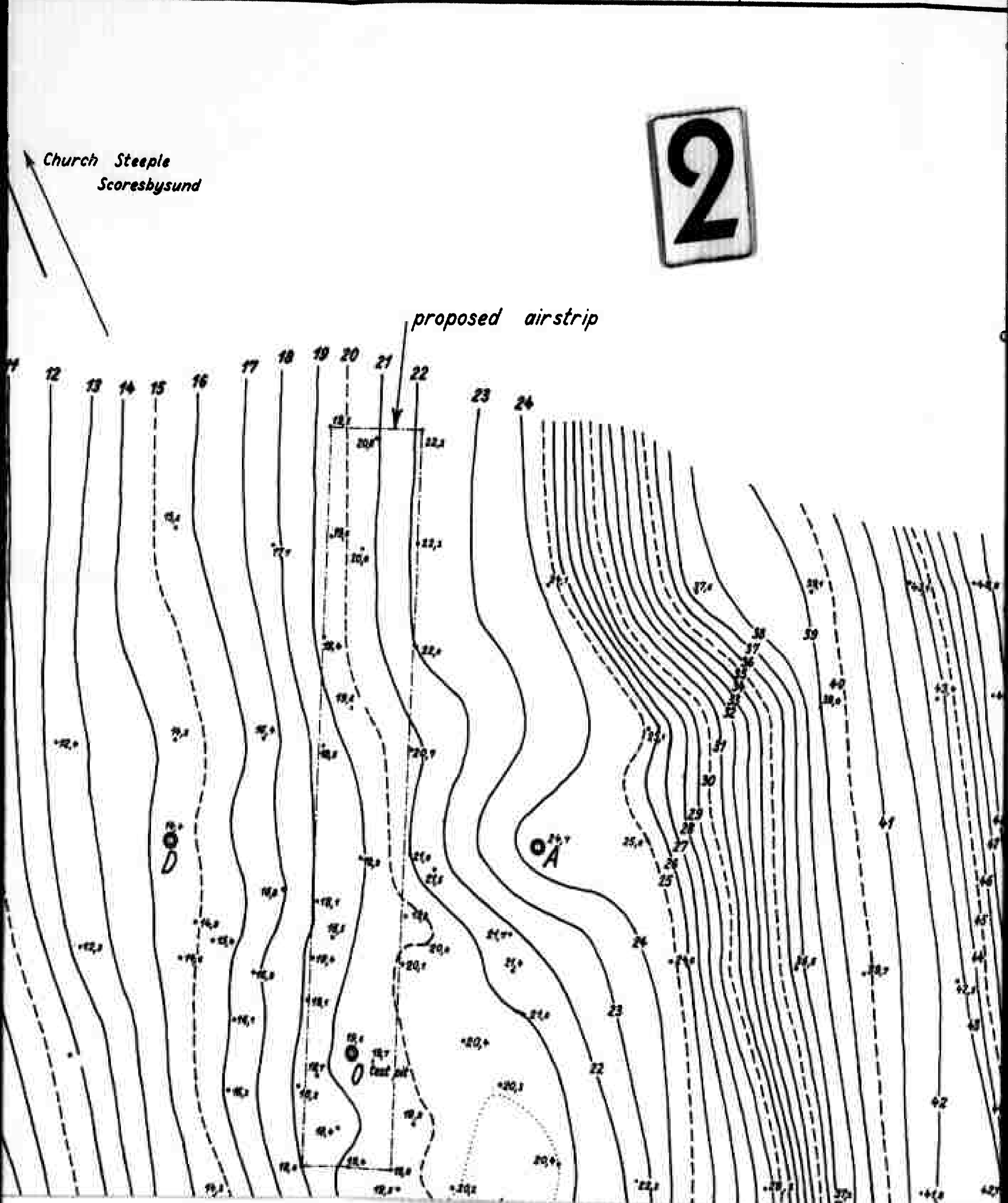
Survey of Jættedal airstrip; approx 70°31'N, 22°05'W.

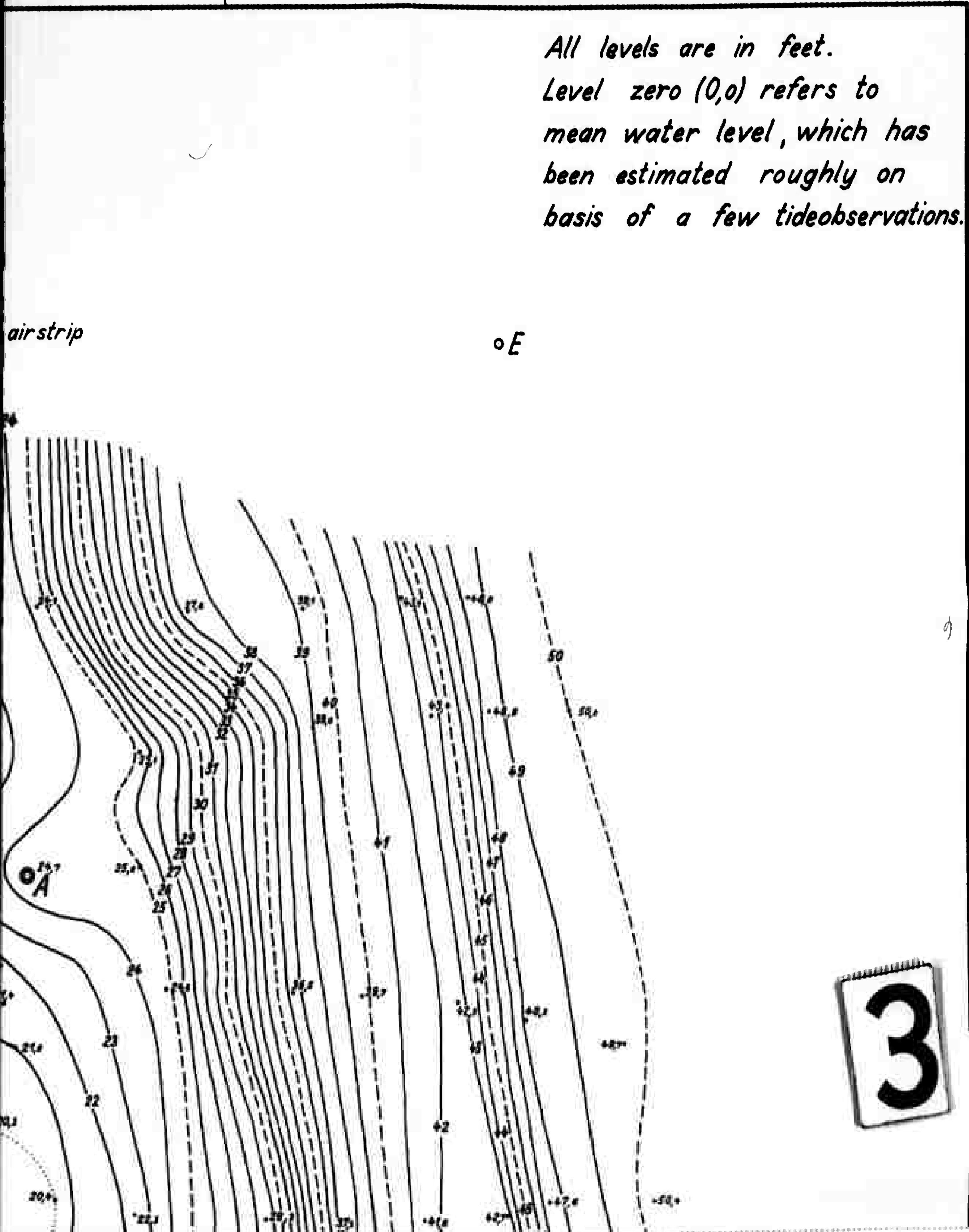
SIGN.:	Opmålt: 21. aug. 1959, SND/LRS/OS	Rev.:
	Tegnet: Oct. 1959, ESH	d.
	NR. 18010'06	

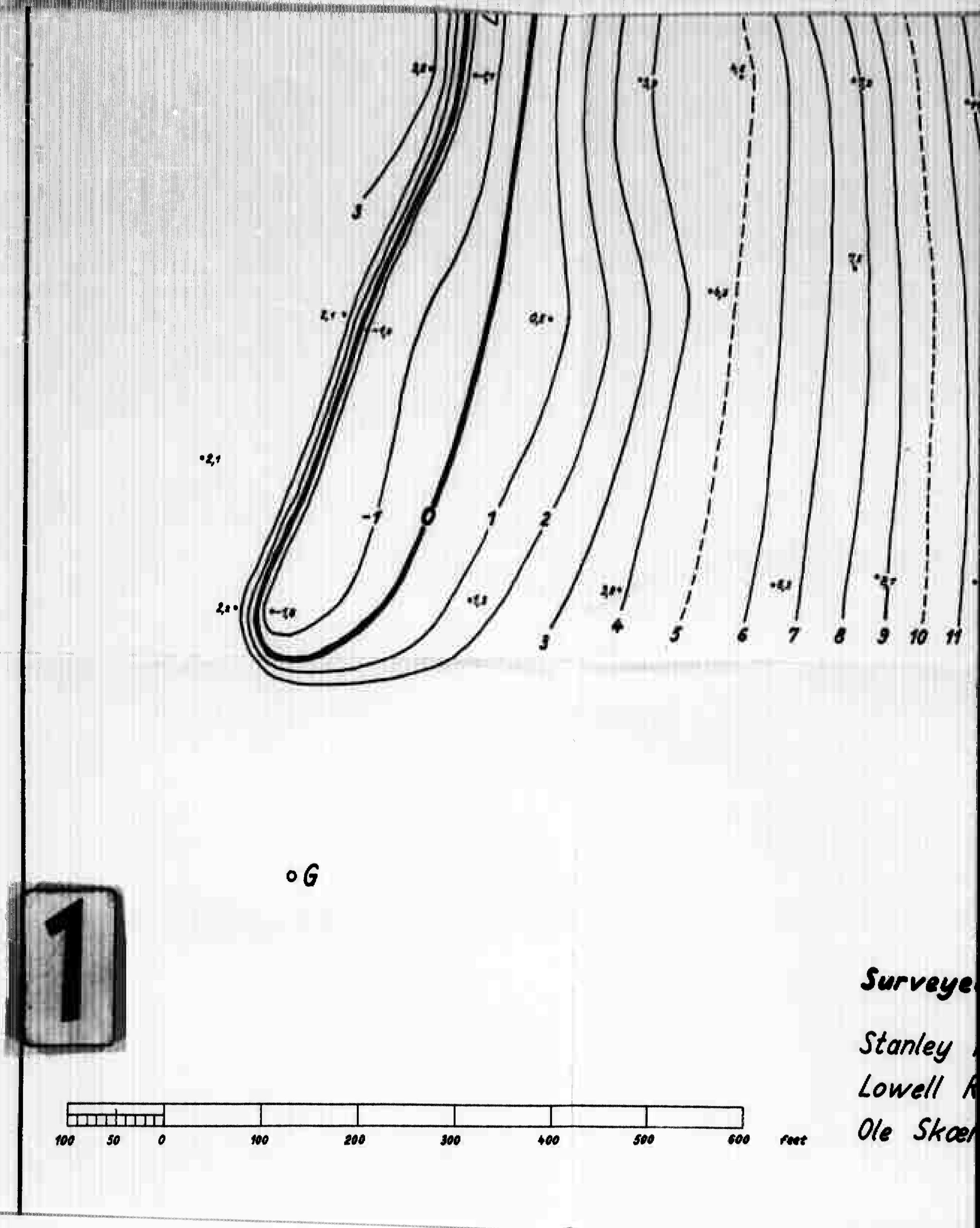
4



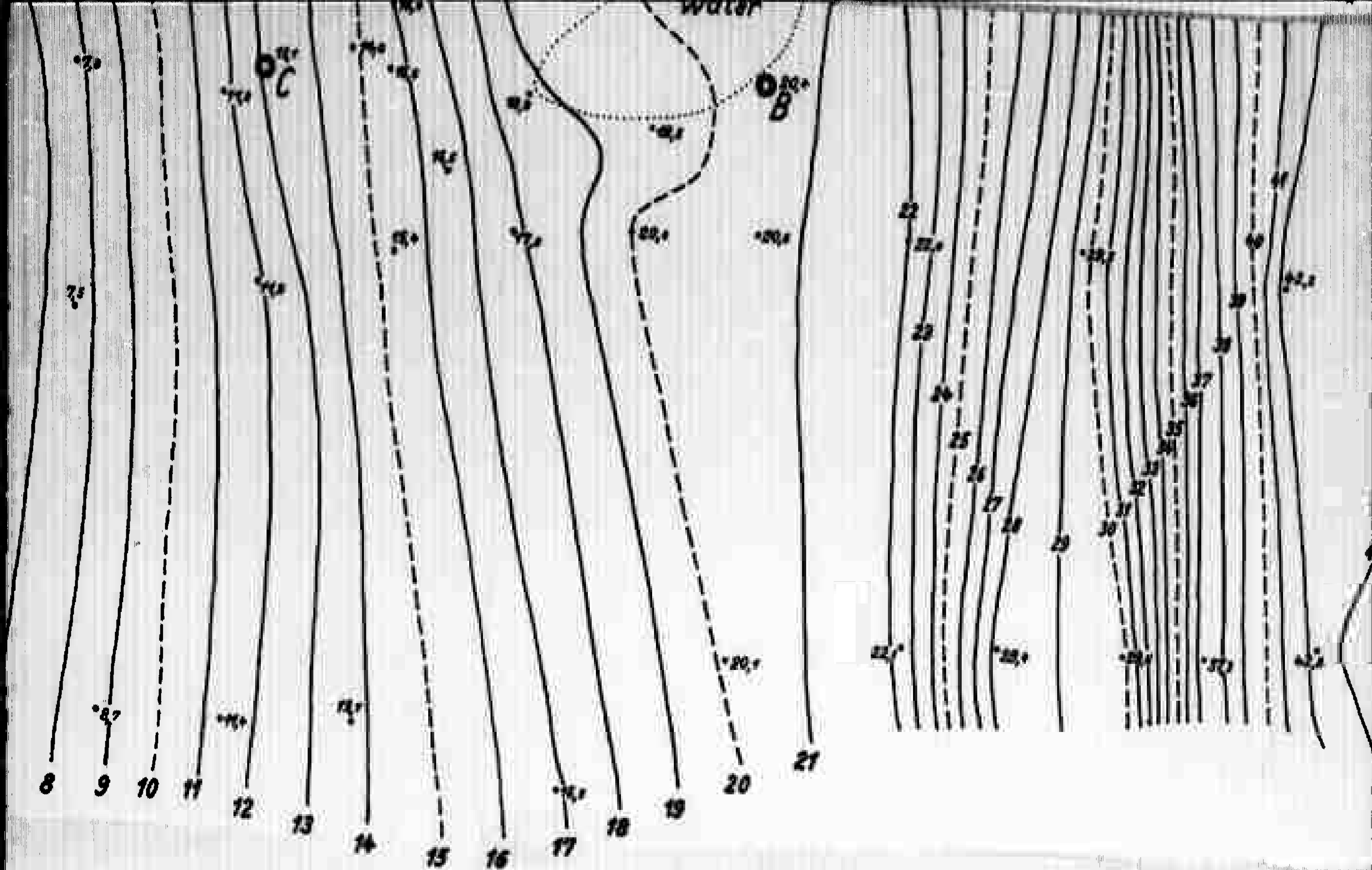
TOPOGRAPHIC MAP OF THE KAP TOBIN SITE


2
Church Steeple
Scoresbysund
proposed airstrip
D
A
O
test pit


All levels are in feet.
Level zero (0,0) refers to mean water level, which has been estimated roughly on basis of a few tideobservations.
airstrip
E
A



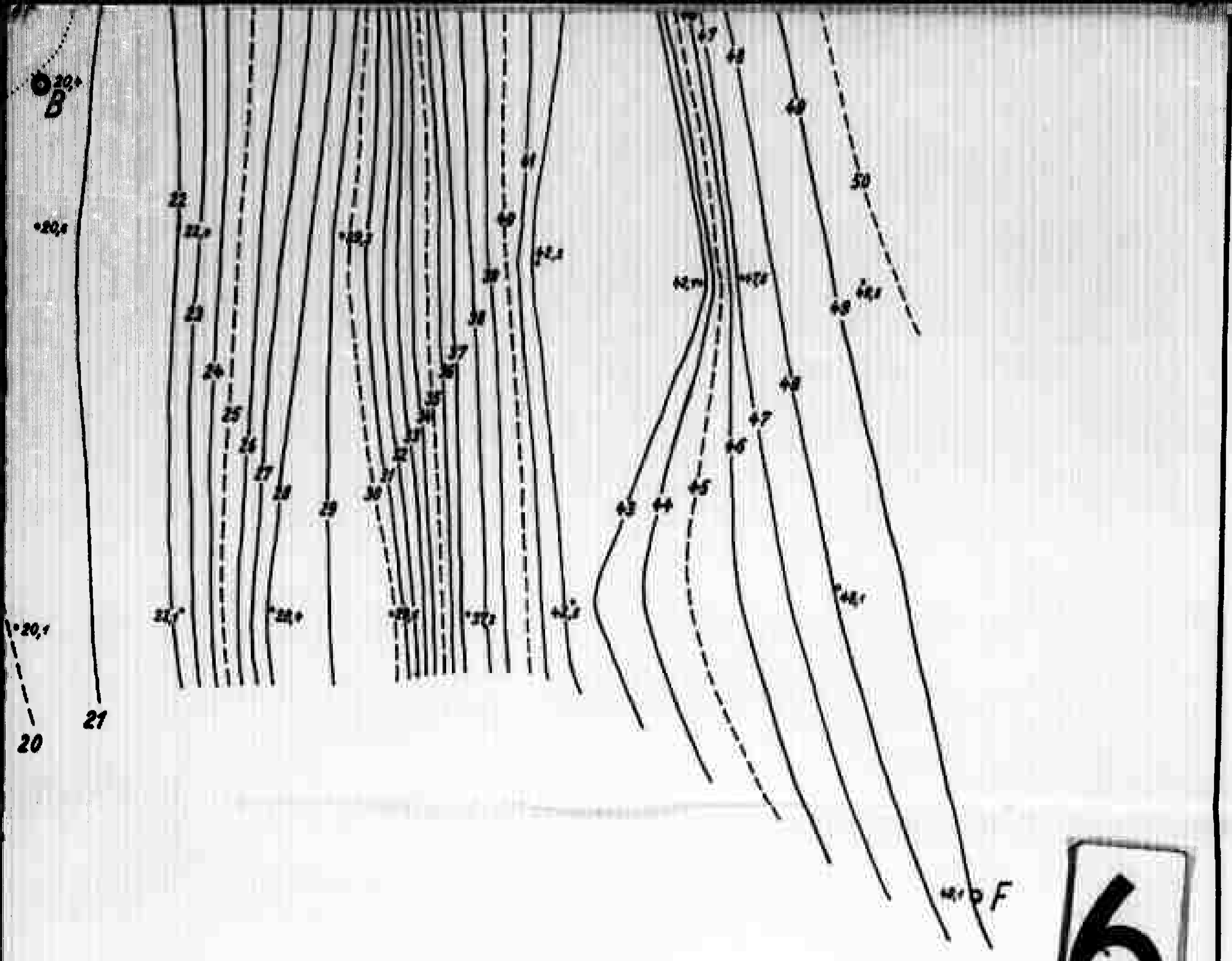
-1
0
1
2
3
4
5
6
7
8
9
10
11
G
1
100 50 0 100 200 300 400 500 600 feet
Surveye
Stanley
Lowell R
Ole Skær



Surveyed 16.-17. august 1959 by:

Stanley N. Davis
Lowell R. Satin
Ole Skærbo

5



6

by:

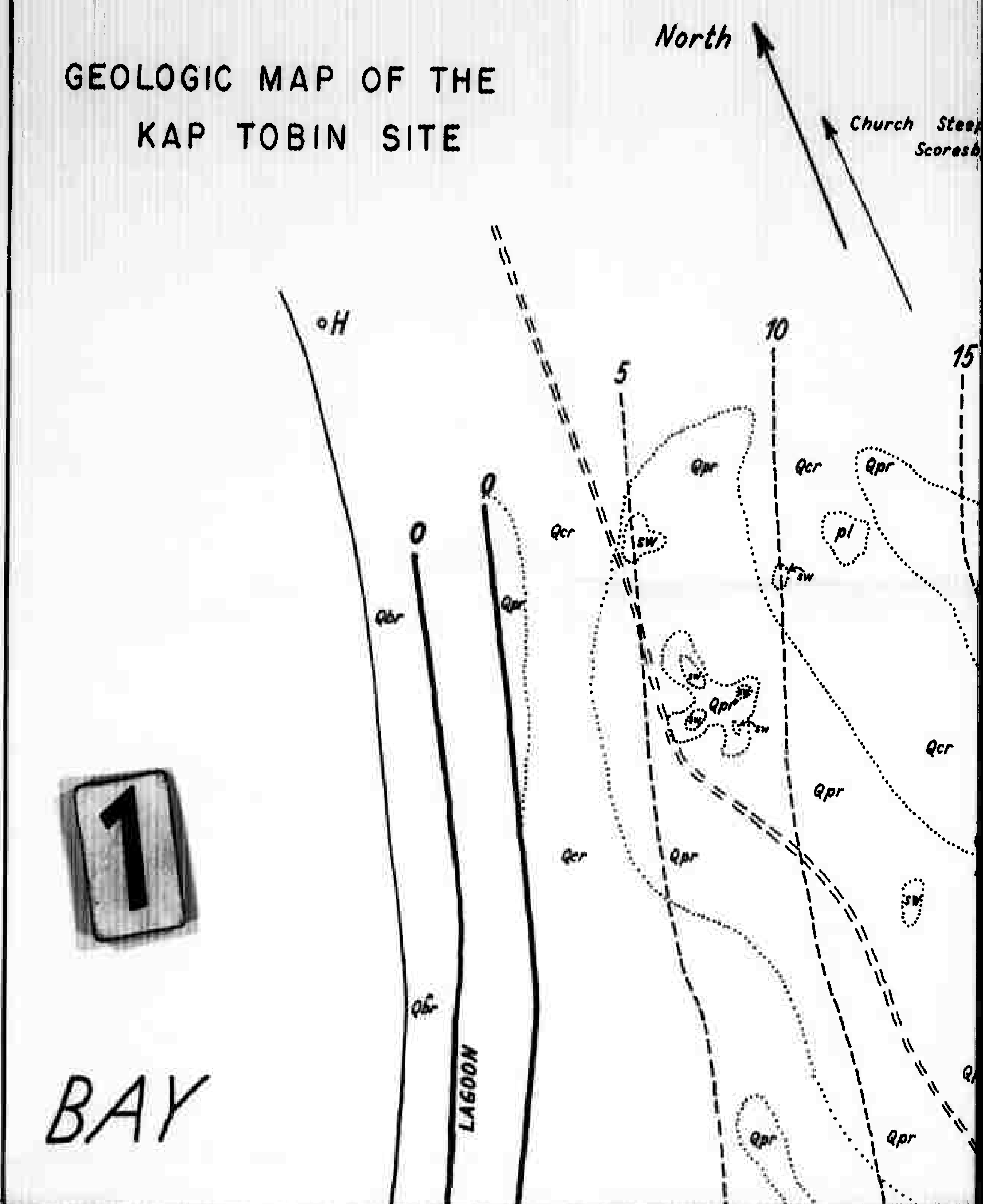
MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

EASTGREENLAND SCORESBYSUND

Survey of airstrip approx.
70°26'N, 21°58'W.

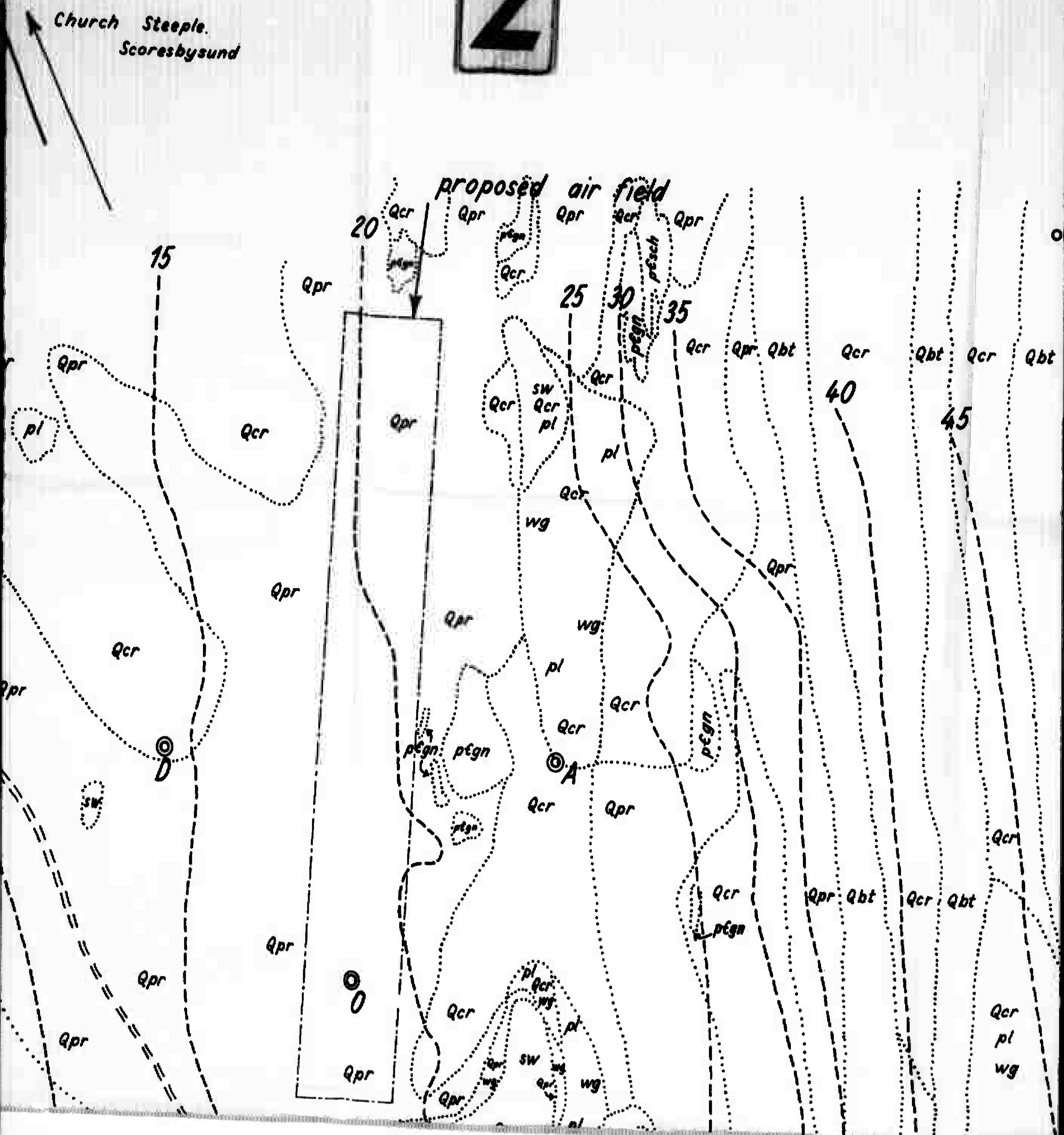
	Opmålt: 16.-17. aug. 1959, SND/LRS/OS		Rev.:
	Tegnet: Nov. 1959, ESH		d.
SIGN.:	NR. 18010'07		

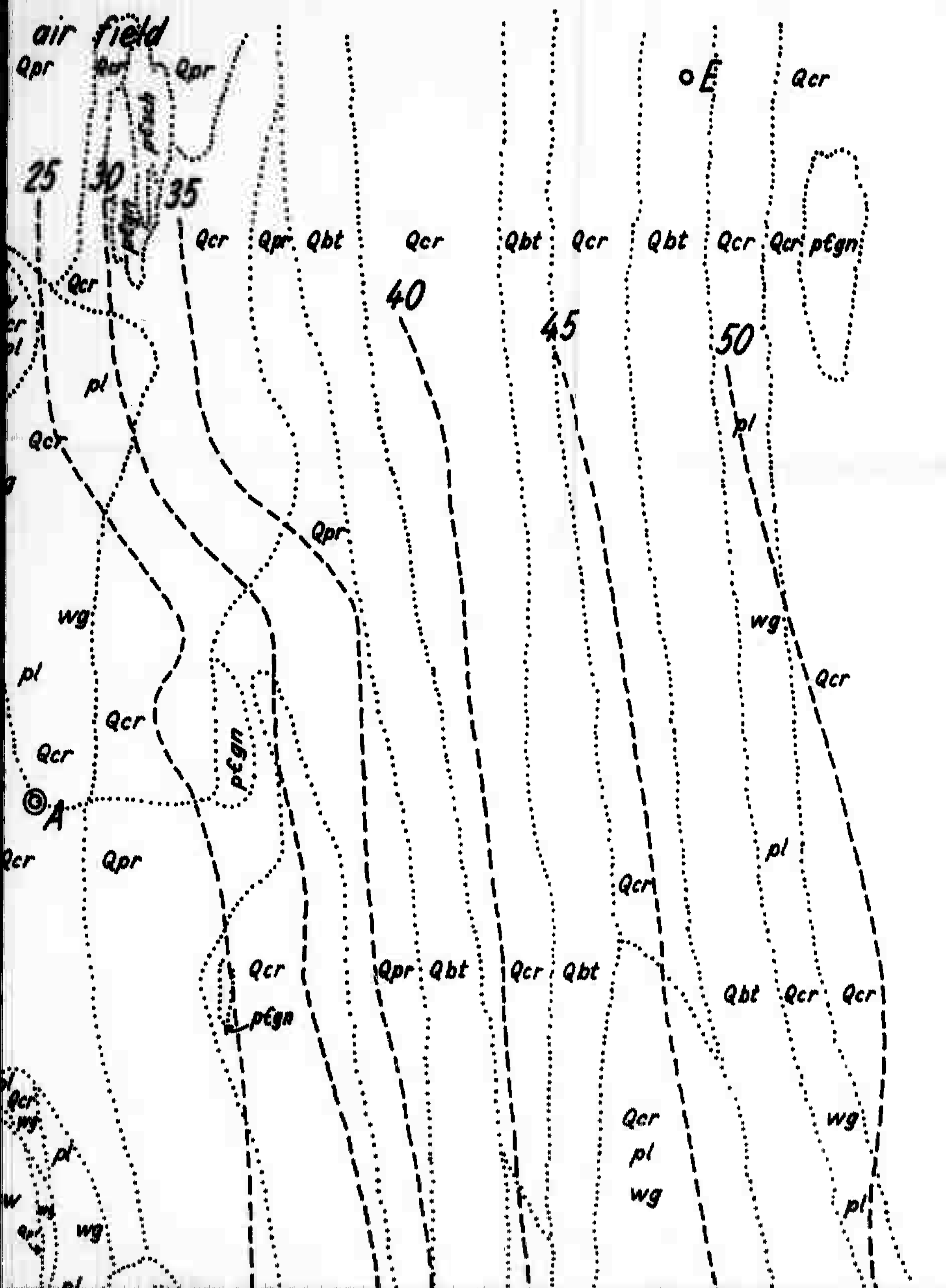
GEOLOGIC MAP OF THE KAP TOBIN SITE



AIR FORCE SURVEYS I

2





All levels are in feet.
Level zero (0,0) refers to mean water level, which has been estimated roughly on basis of a few tideobservations.

EXPLANATION:

B Survey marker.

—— Boundary of proposed air field.

.... Geologic contact.

Qbr - Angular to subangular cobbles. Modern beach ridge.

Qpr - Pebble rubble; scattered large boulders.

Qcr - Cobble rubble; scattered large boulders.

Qbt - Former beach ridge, now part of marine terrace.

p€gn - Granite gneiss.

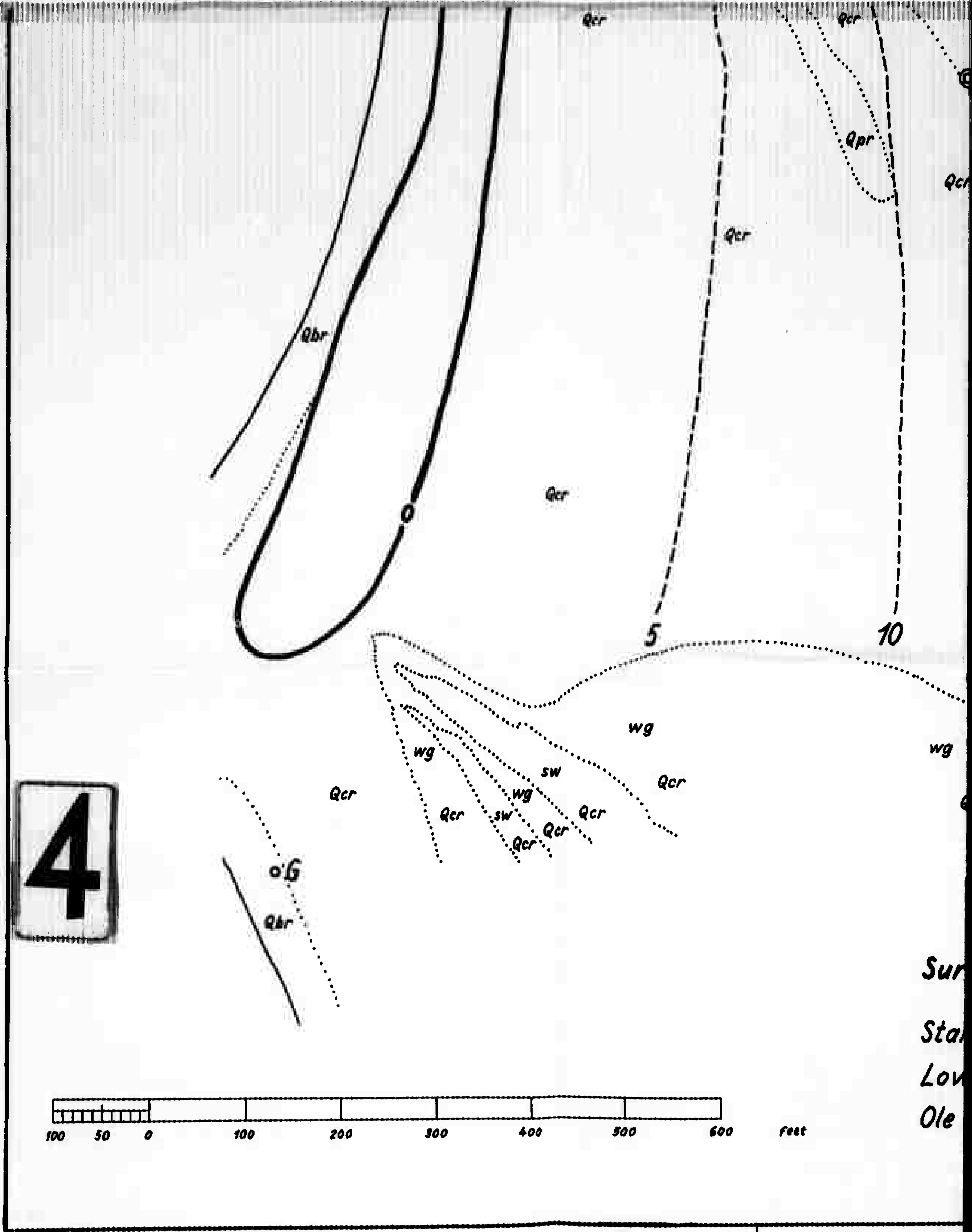
p€sch - Schist.

pl - Stone polygons.

sw - Standing water, shallow; cobbles protruding above water.

wg - wet ground.

3



Qcr
Qcr
Qpr
Qcr
Qbr
Qcr
Qcr
0
5
10
wg
wg
sw
Qcr
wg
Qcr
Qcr
wg
sw
Qcr
Qcr
Qcr
G
Qbr
4
Sur
Sta
Lov
Ole
100
50
0
100
200
300
400
500
600
feet

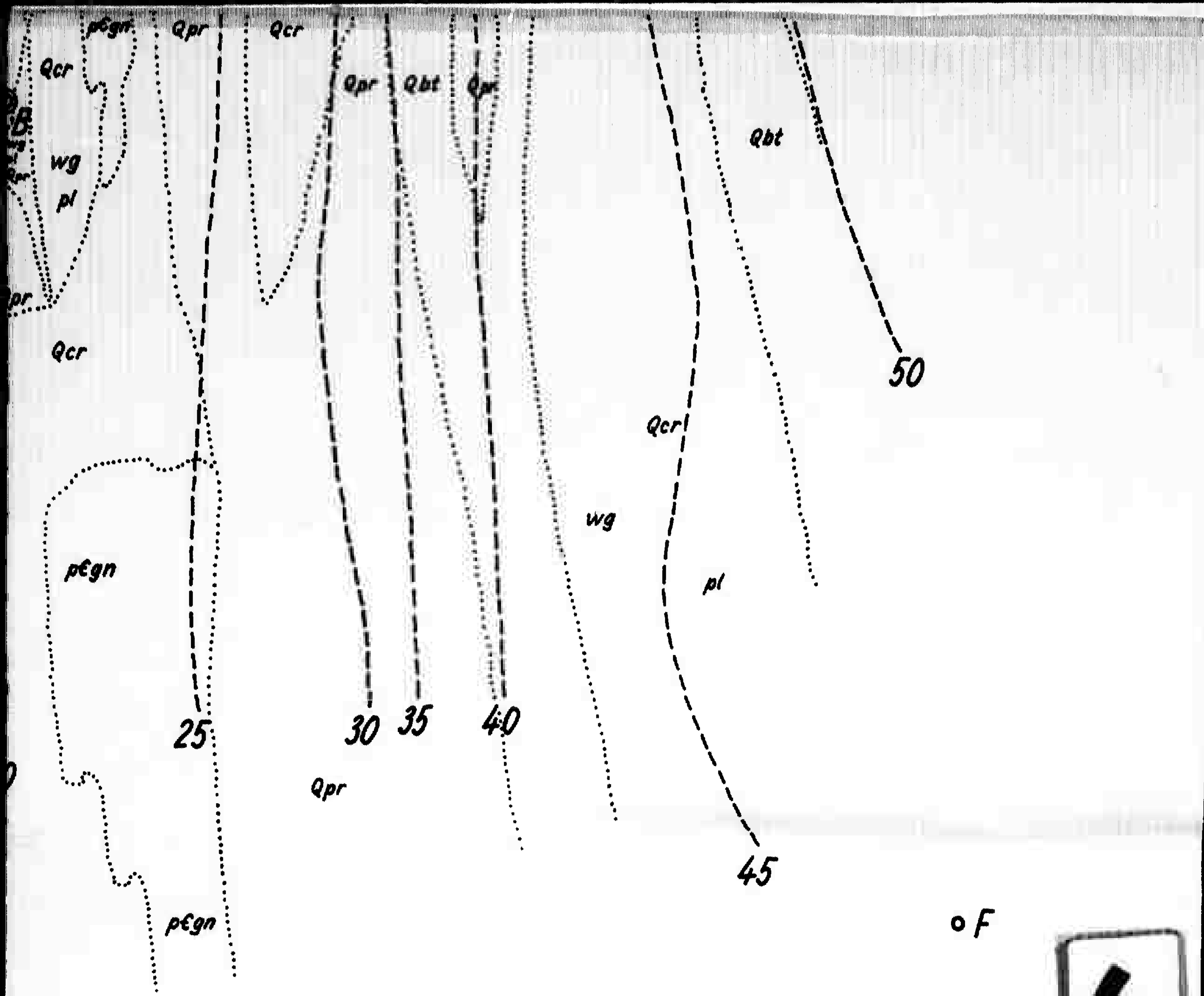
Surveyed 16.-17. august 1959 by:

Stanley N. Davis
Lowell R. Satin
Ole Skærbo

5

EAS
Surv
with

SIGN.:



6

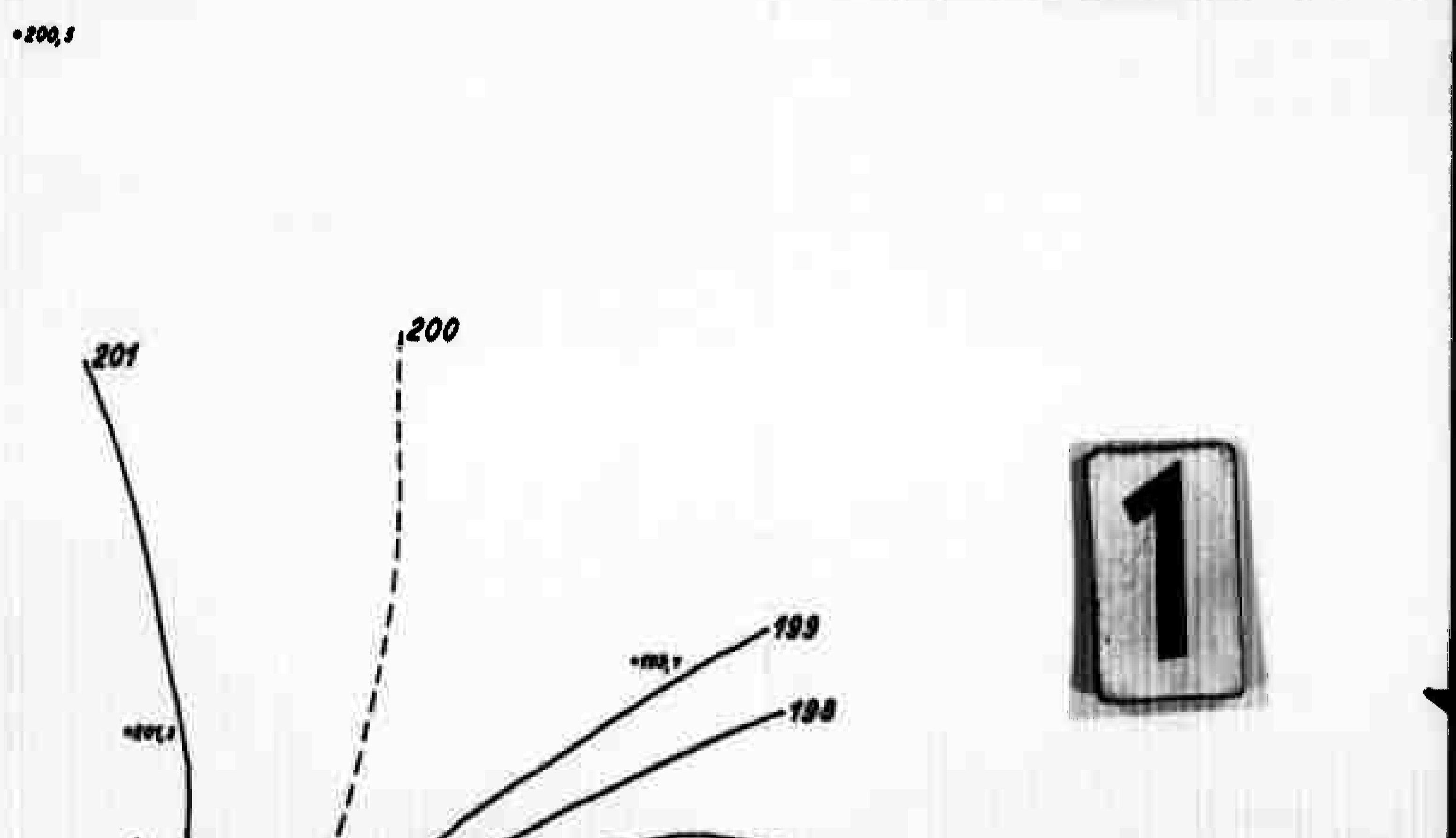
by :

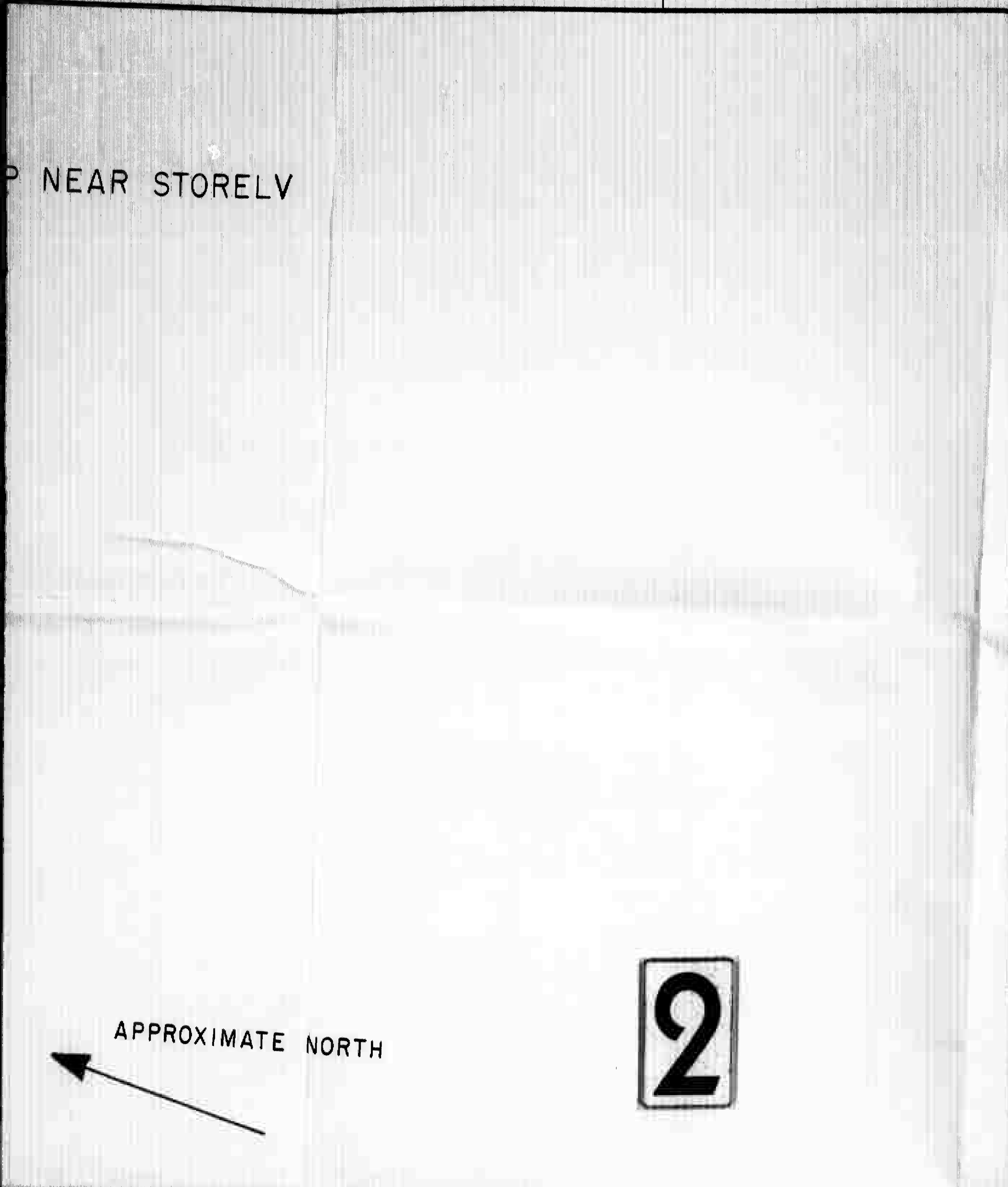
MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

EASTGREENLAND SCORESBYSUND
Survey of airstrip approx. 70°26'N, 21°58'W
with geology by S.N.Davis and L.R.Satin

Opmålt: 16.-17. aug. 1959, SND/LRS/OS		Rev.:
Tegnet: Nov. 1959, ESH		d.
SIGN.: NR. 18010'08		

TOPOGRAPHIC MAP OF SURVEYED AIRSTRIP NE




P NEAR STORELV
APPROXIMATE NORTH
2

All levels are in feet referring to an estimated level of Origin to be 200,0 feet.

Surveyed September 1959 by:

Stanley N. Davis

George E. Stoerts

Lowell R. Satin

Ole Skaerbo

4

All levels are in feet referring to an estimated level of Origin to be 200,0 feet.

Surveyed September 1959 by:

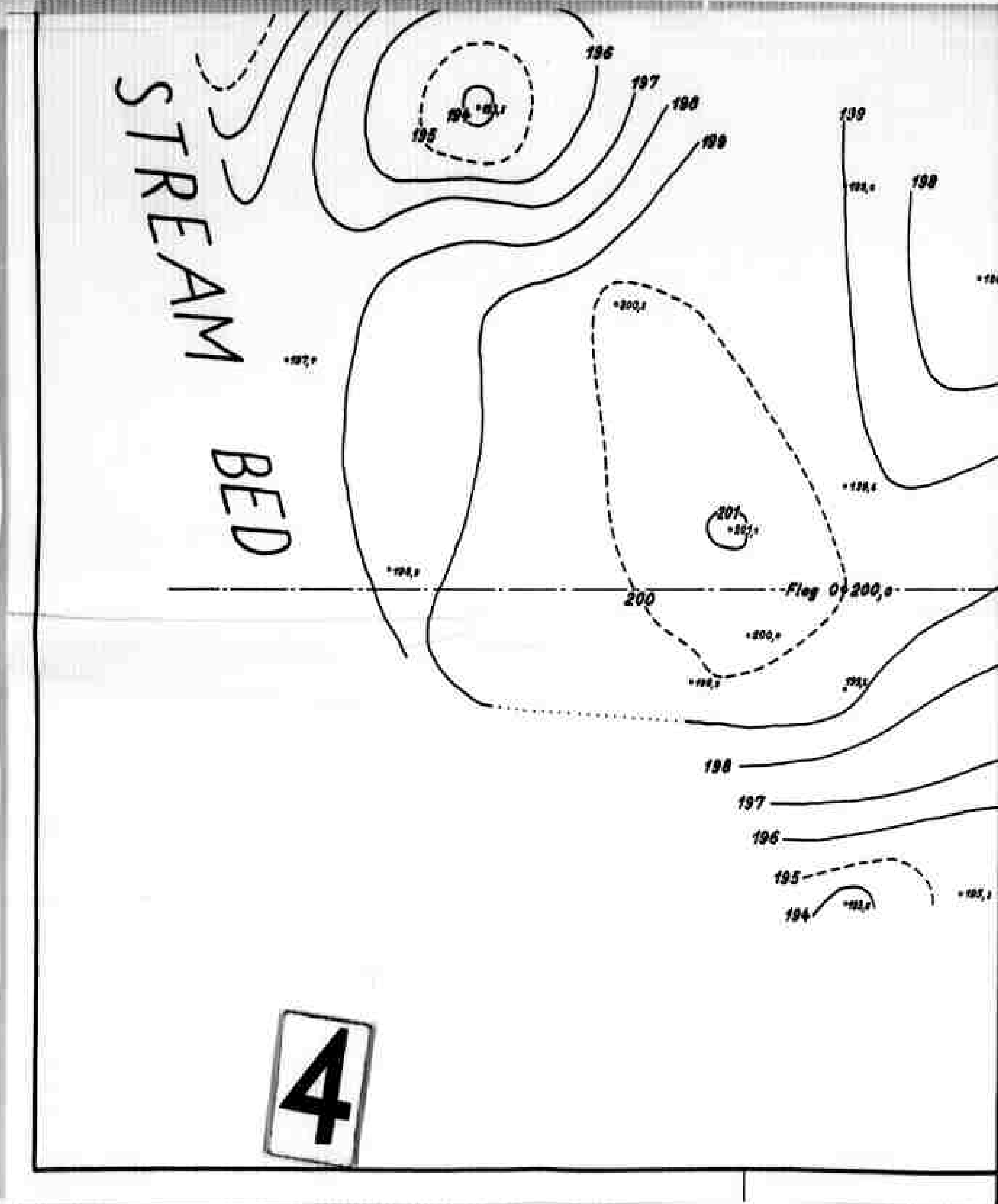
Stanley N. Davis

George E. Stoerts

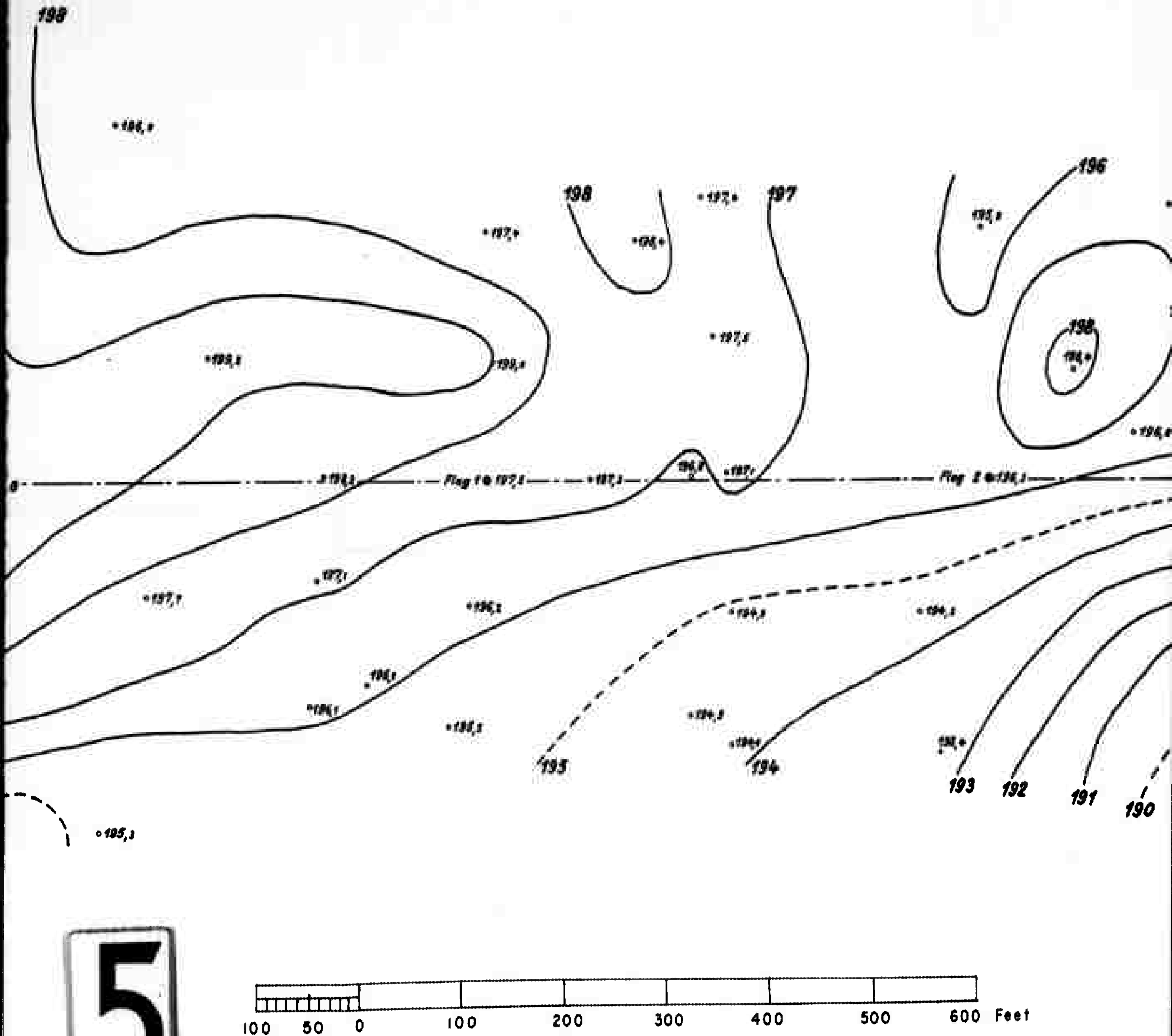
Lowell R. Satin

Ole Skærbo

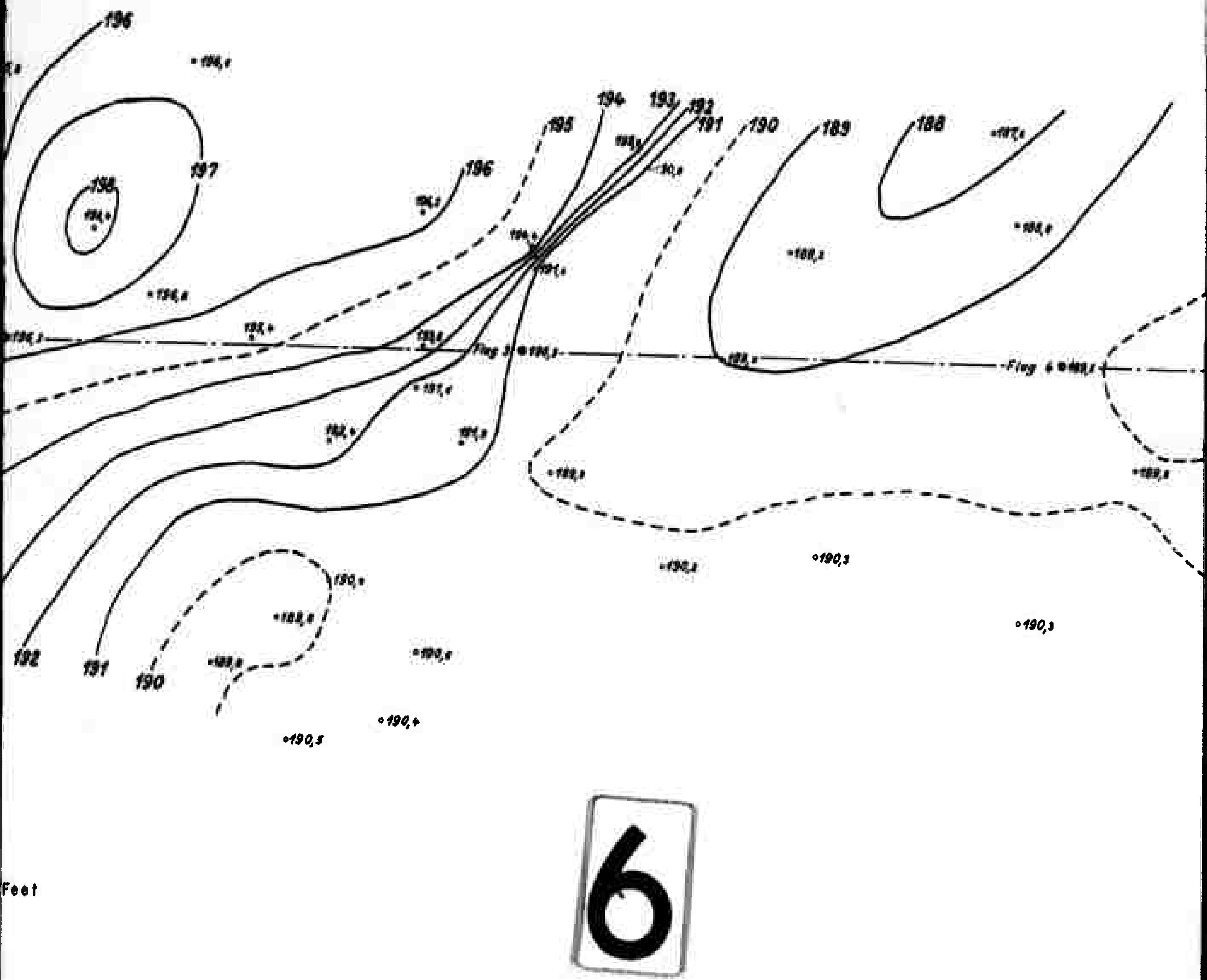
3

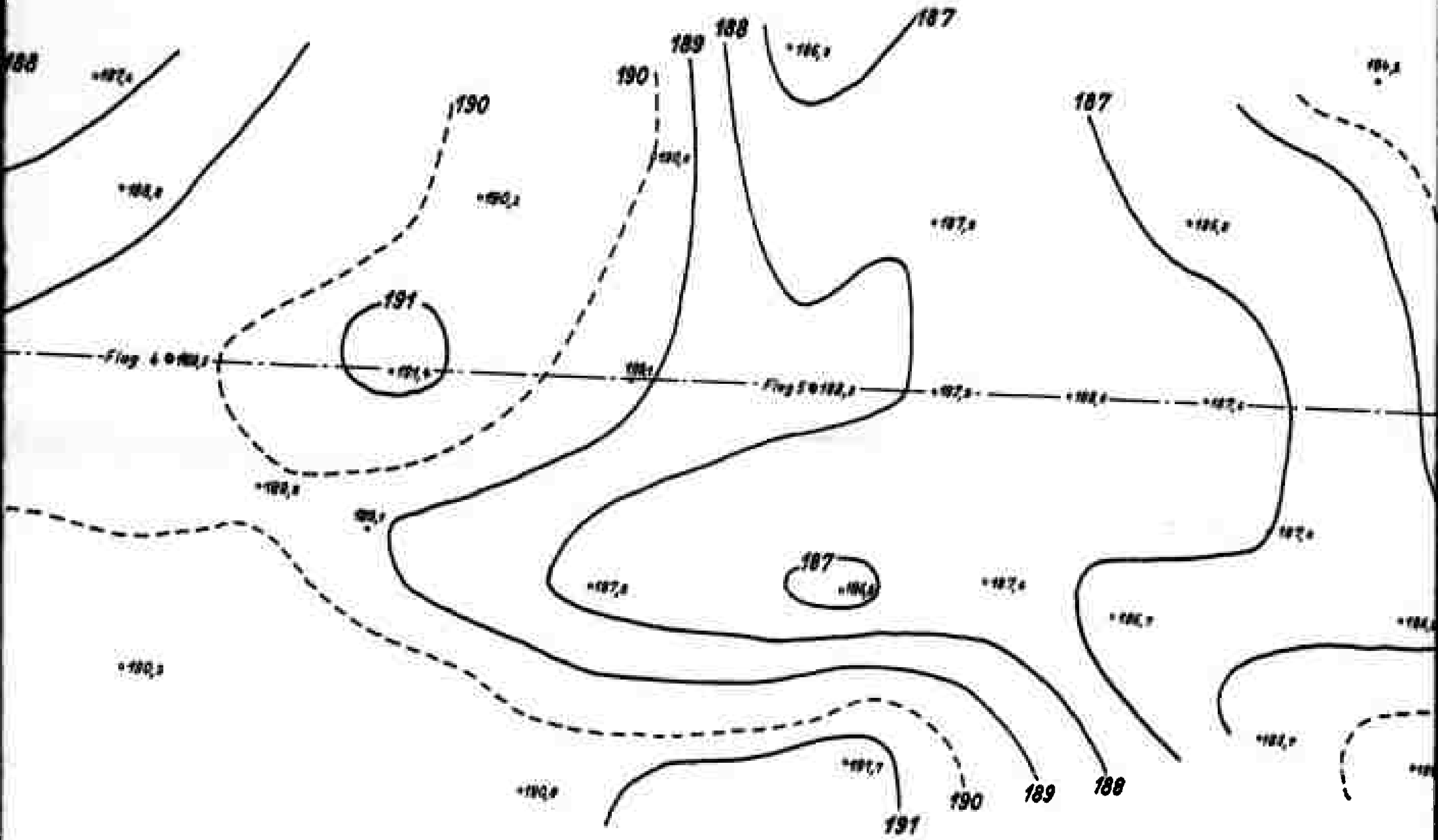


STREAM BED
196
197
198
199
195
201
200
198
197
196
195
194
4


198
198
197
196
198
Flag 1
Flag 2
195
194
193
192
191
190
195,3
100 50 0 100 200 300 400 500 600 Feet

5


196
197
198
196
195
194
193
192
191
190
189
188
Flag 3
Flag 4
190,3
190,3
190,4
190,5
192
191
190
Feet
6



7

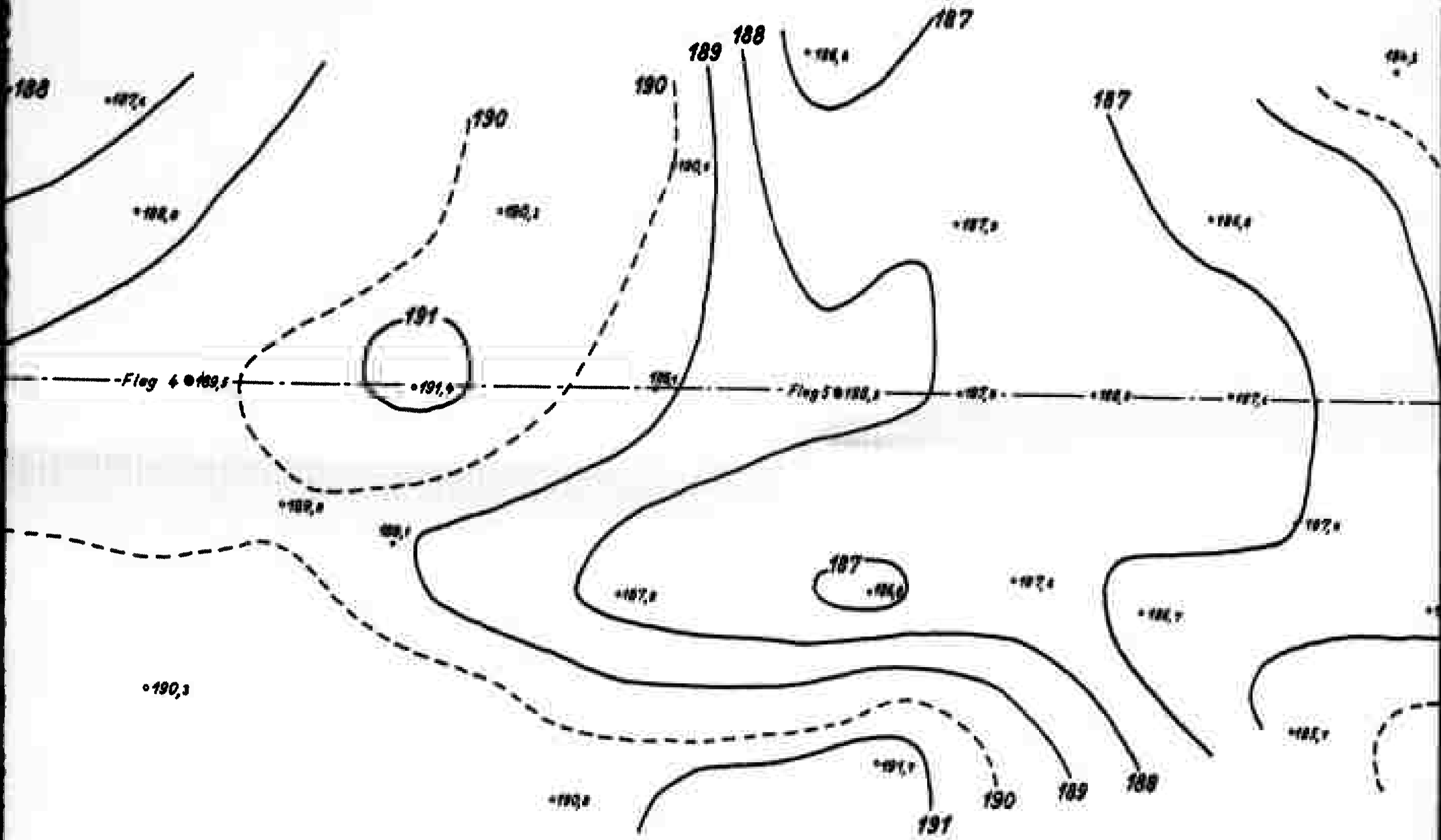
MINISTERIET FOR G

EASTGREENLAND 73°

Survey of Stordal a

Flag 0 - flag 6

SIGN.:	Opmålt: Sep. 1959, SND/GES
	Tegnet: Oct. 1959, ESH
	NR. 19283'01



8

MINISTERIET FOR

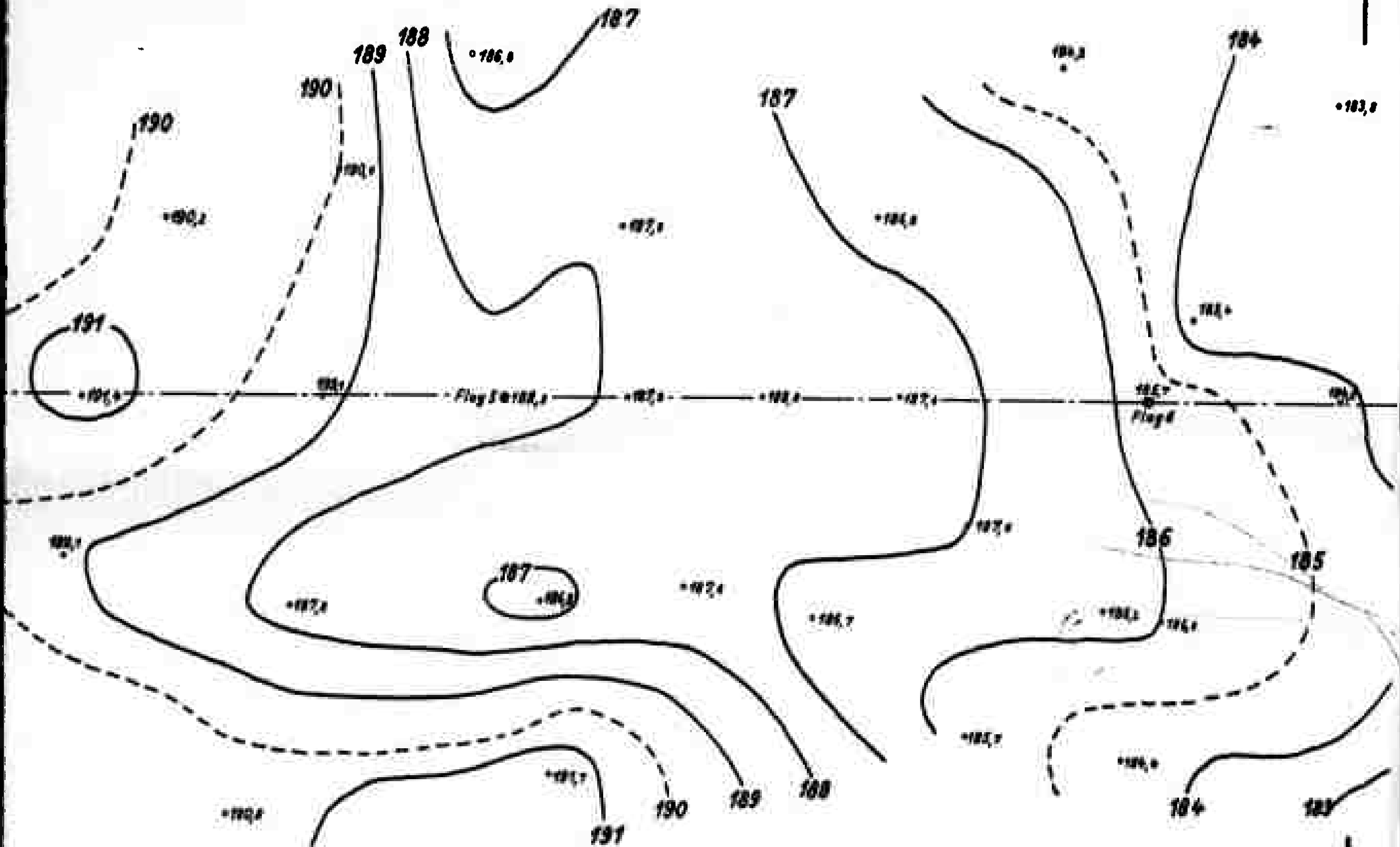
EASTGREENLAND 7

Survey of Stordal

Flag 0 - flag 6

	Opmålt: Sep.1959, SND/
	Tegnet: Oct. 1959, ES
SIGN.:	NR. 19283'01

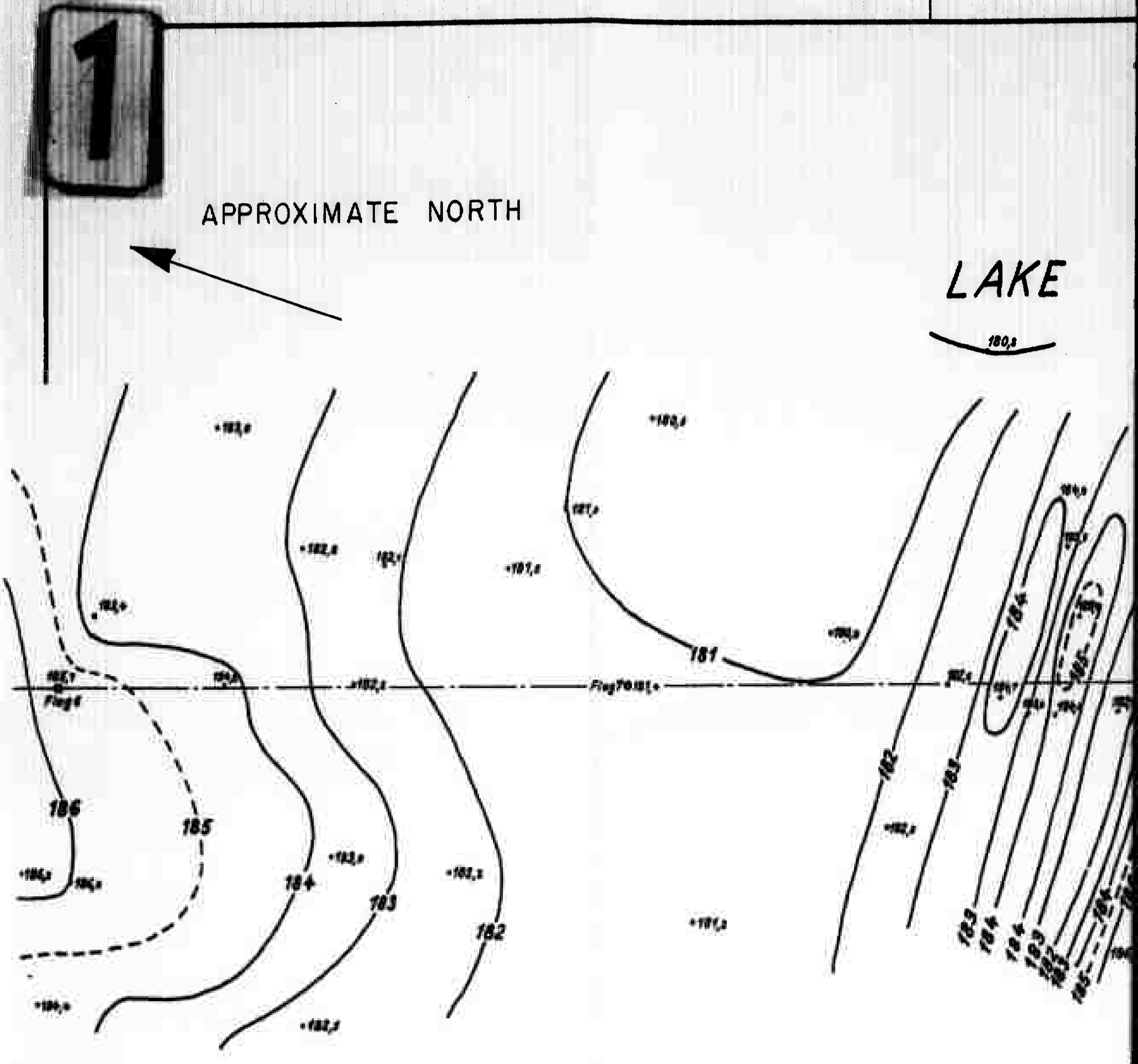
9



MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

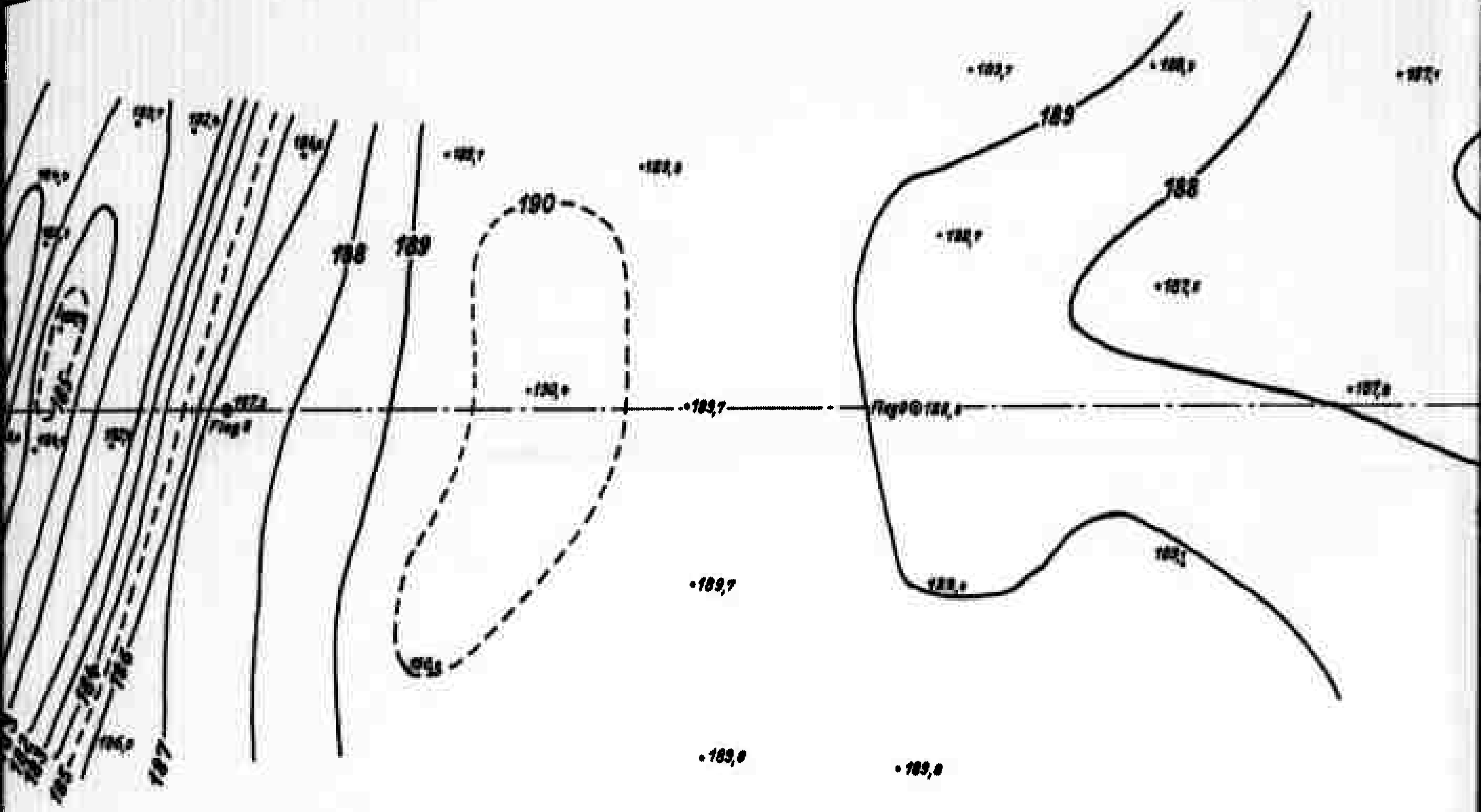
EASTGREENLAND 73°39'N, 22°05'W
Survey of Stordal airstrip
Flag 0 - flag 6

Opmålt: Sep. 1959, SND/GES/LRS/OS
Tegnet: Oct. 1959, ESH
NR. 19283'01
Rev.:
d.
SIGN.:



TOPOGRAPHIC MAP OF SURVEYED AIRSTRIP N

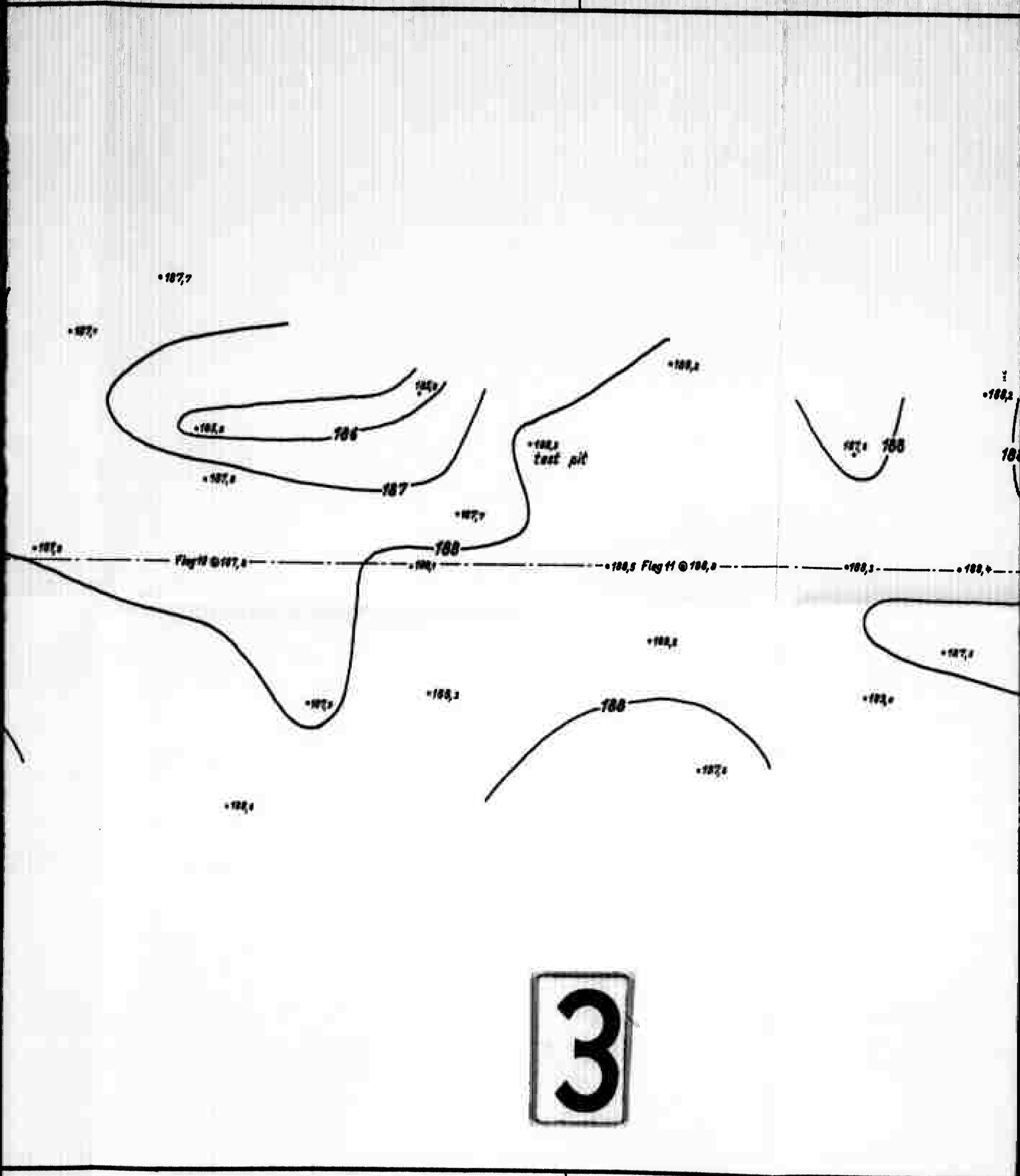
100 50 0 100 200 300 400 500 600



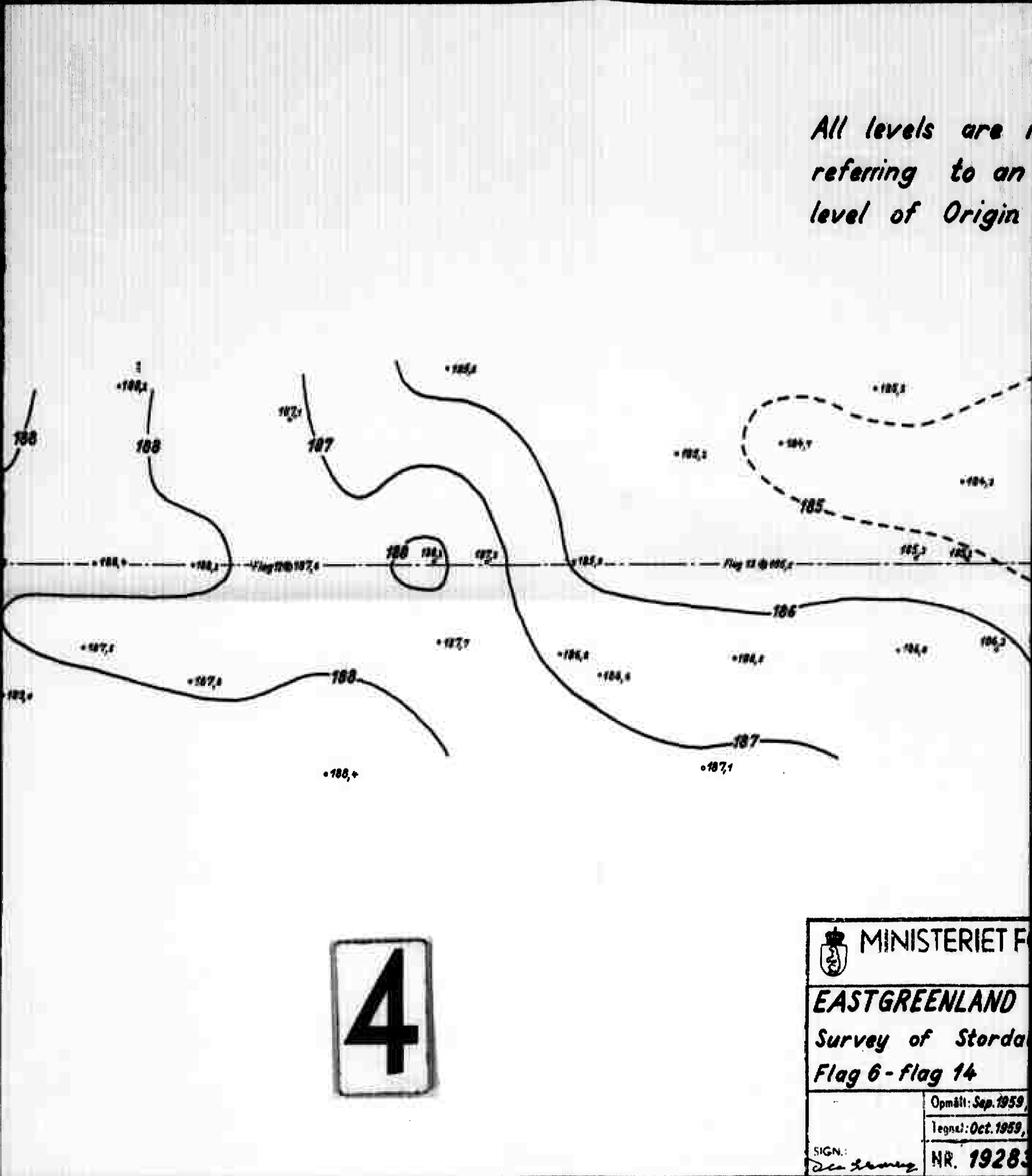
RIP NEAR STORELV

600 Feet

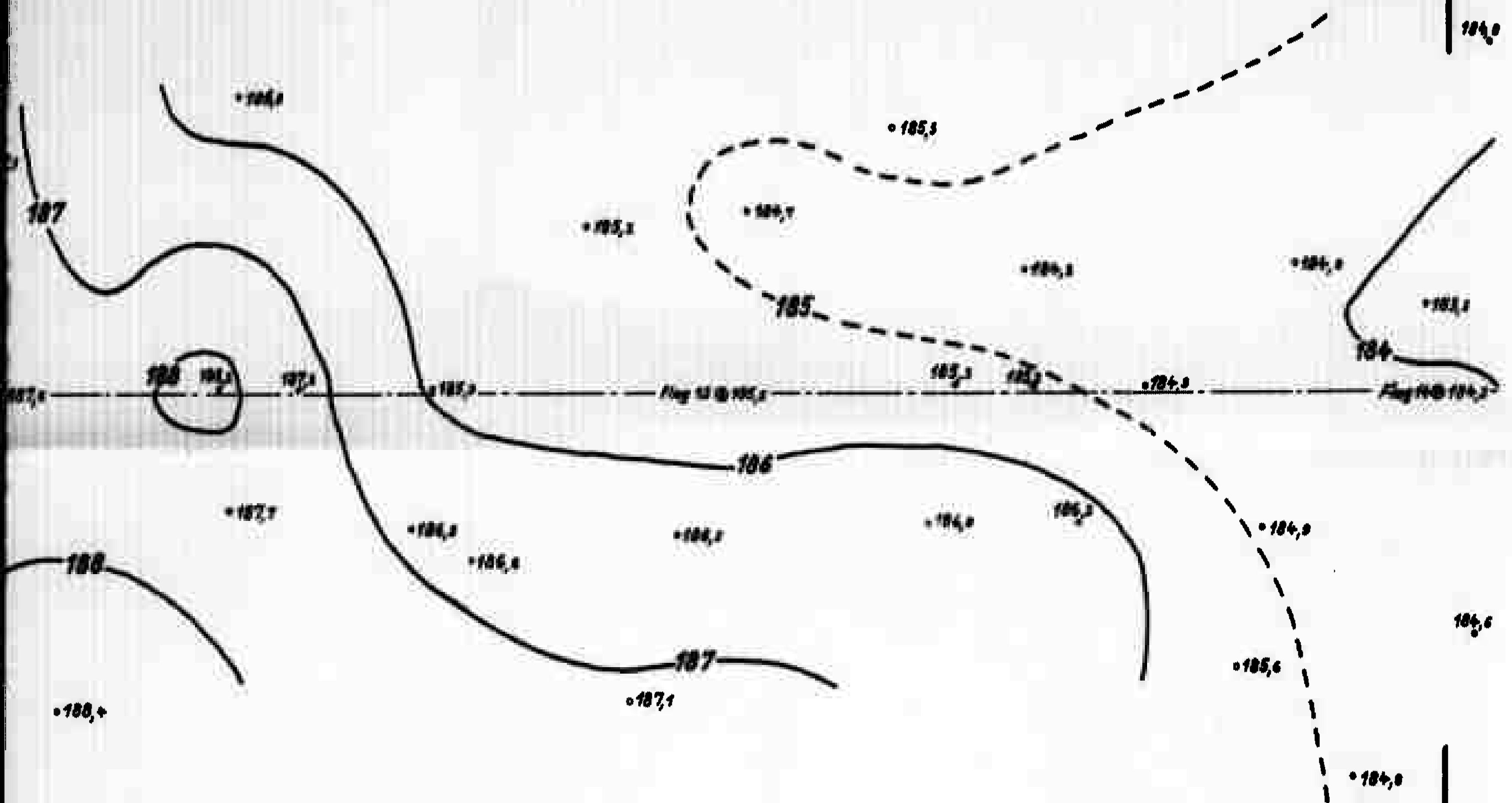
2



186
187
188
test pit
3


All levels are
referring to an
level of Origin
188
188
187
186
185
186
187
188
Flag 12
Flag 13
4
MINISTERIET F
EASTGREENLAND
Survey of Storda
Flag 6 - flag 14
Opmålt: Sep. 1959
Tegnet: Oct. 1959
SIGN.:
NR. 1928

All levels are in feet referring to an estimated level of Origin to be 200,0 feet.

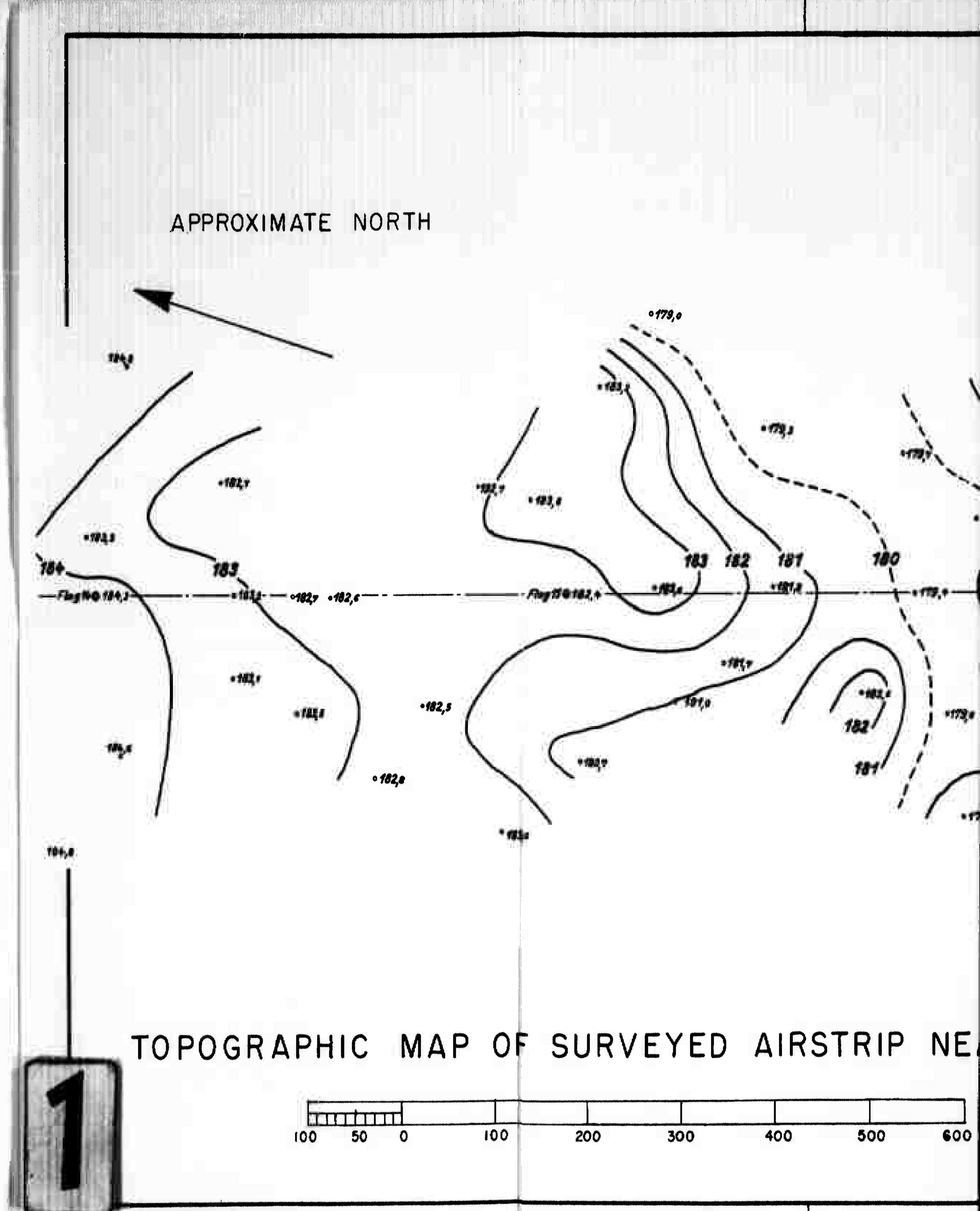


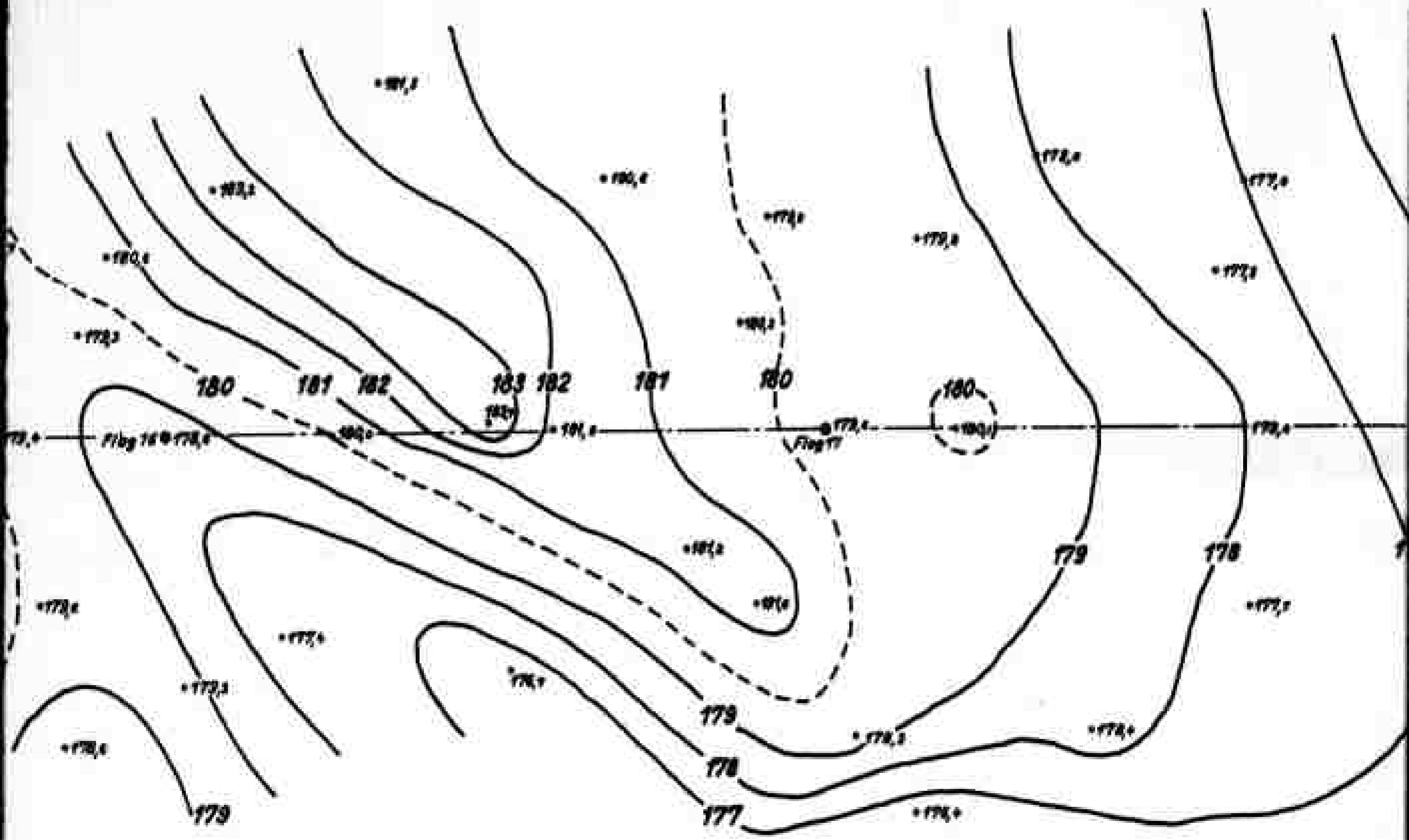
5

MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

EASTGREENLAND 73°39'N, 22°05'W
Survey of Stordal airstrip
Flag 6 - flag 14

	Opmålt: Sep. 1959, SND/GES/LRS/OS	Rev.:
	Tegnet: Oct. 1959, ESH	d.
SIGN.:	NR. 19283'02	


APPROXIMATE NORTH
179,0
184
183
183
182
181
180
182,7
182,6
182,5
182,8
182
181
TOPOGRAPHIC MAP OF SURVEYED AIRSTRIP NE
100 50 0 100 200 300 400 500 600
1

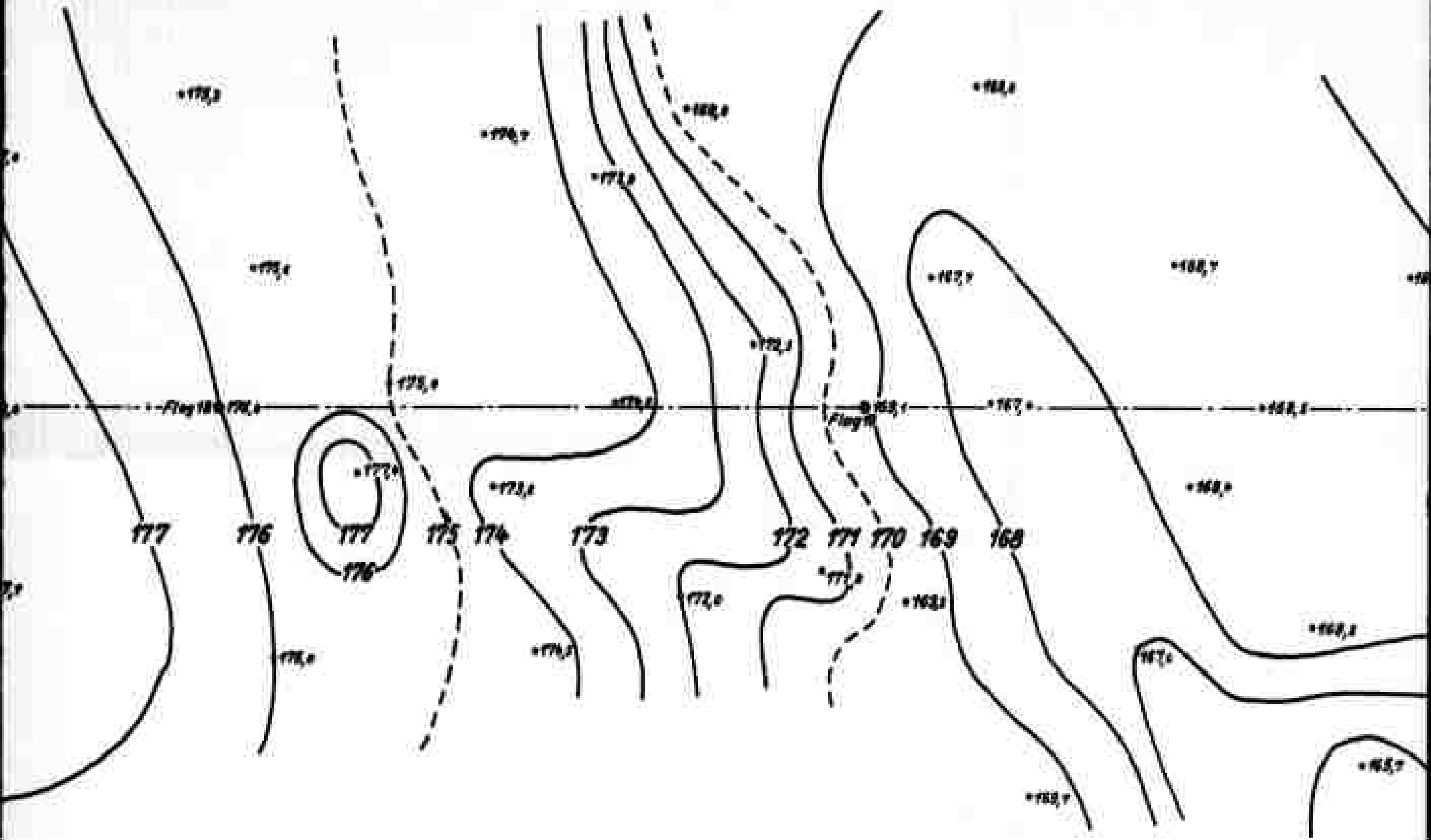


NEAR STORELV

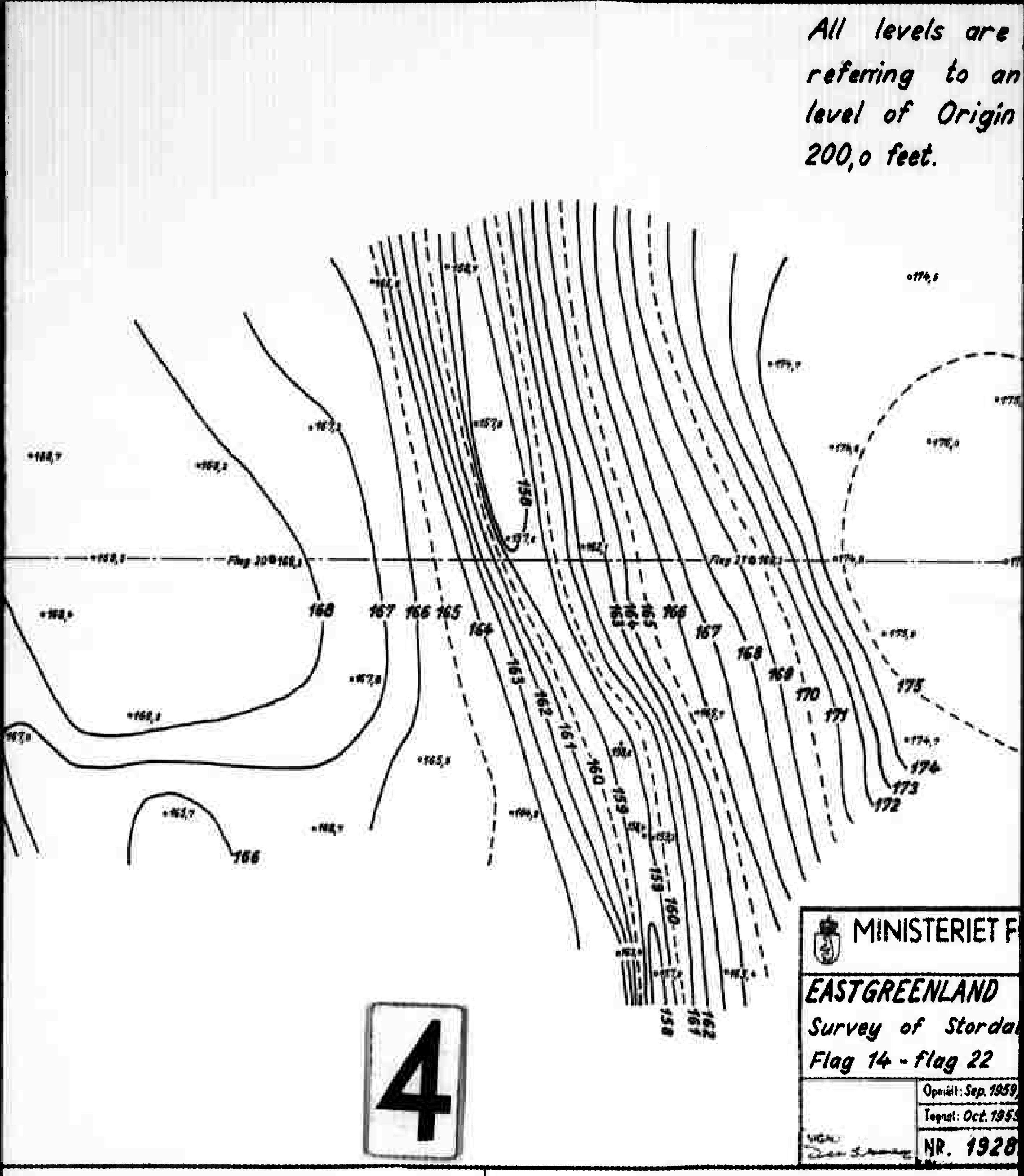
600 Feet

2

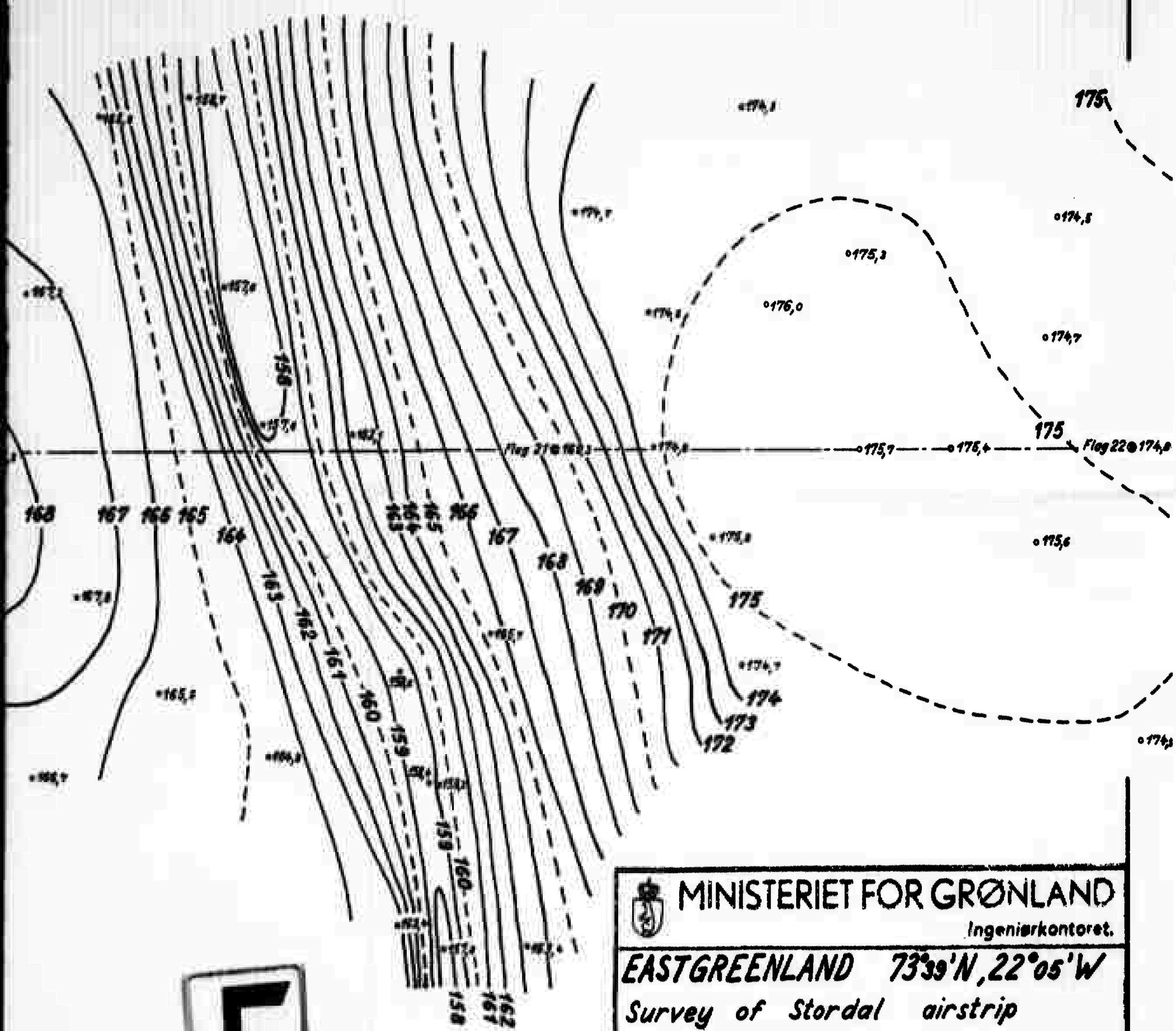
AIR



3


All levels are
referring to an
level of Origin
200,o feet.
Flag 20
Flag 21
168
167
166
165
164
163
162
161
160
159
158
170
171
172
173
174
175
MINISTERIET F
EASTGREENLAND
Survey of Stordal
Flag 14 - flag 22
Opmålt: Sep. 1959
Tegnet: Oct. 1959
NR. 1928
4

All levels are in feet referring to an estimated level of Origin to be 200,0 feet.



5

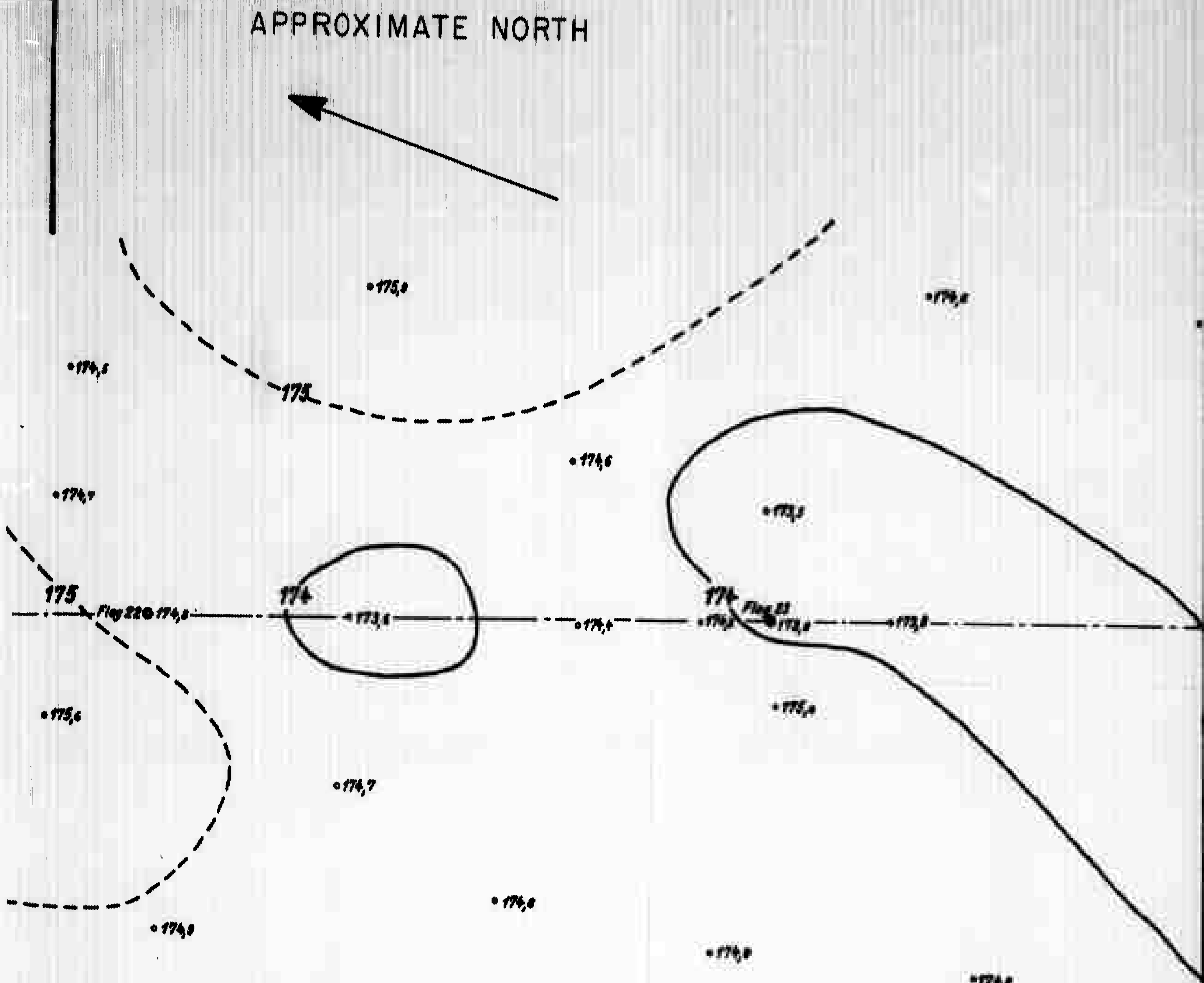
MINISTERIET FOR GRØNLAND
Ingeniørkontoret.

EASTGREENLAND 73°39'N, 22°05'W

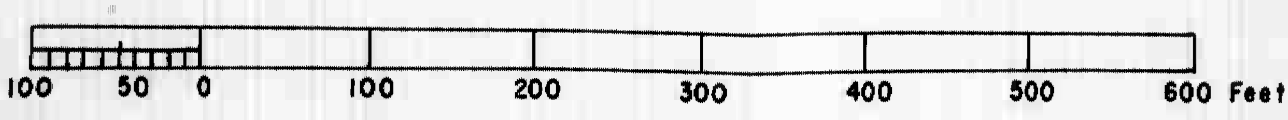
Survey of Stordal airstrip

Flag 14 - flag 22

	Opmålt: Sep. 1959, SND/GES/LRS/OS	Rev.:
	Tegnet: Oct. 1959, ESH	d.
SIGN.:	NR. 19283'03	



TOPOGRAPHIC MAP OF SURVEYED AIRSTRIP NEAR STORELV



1

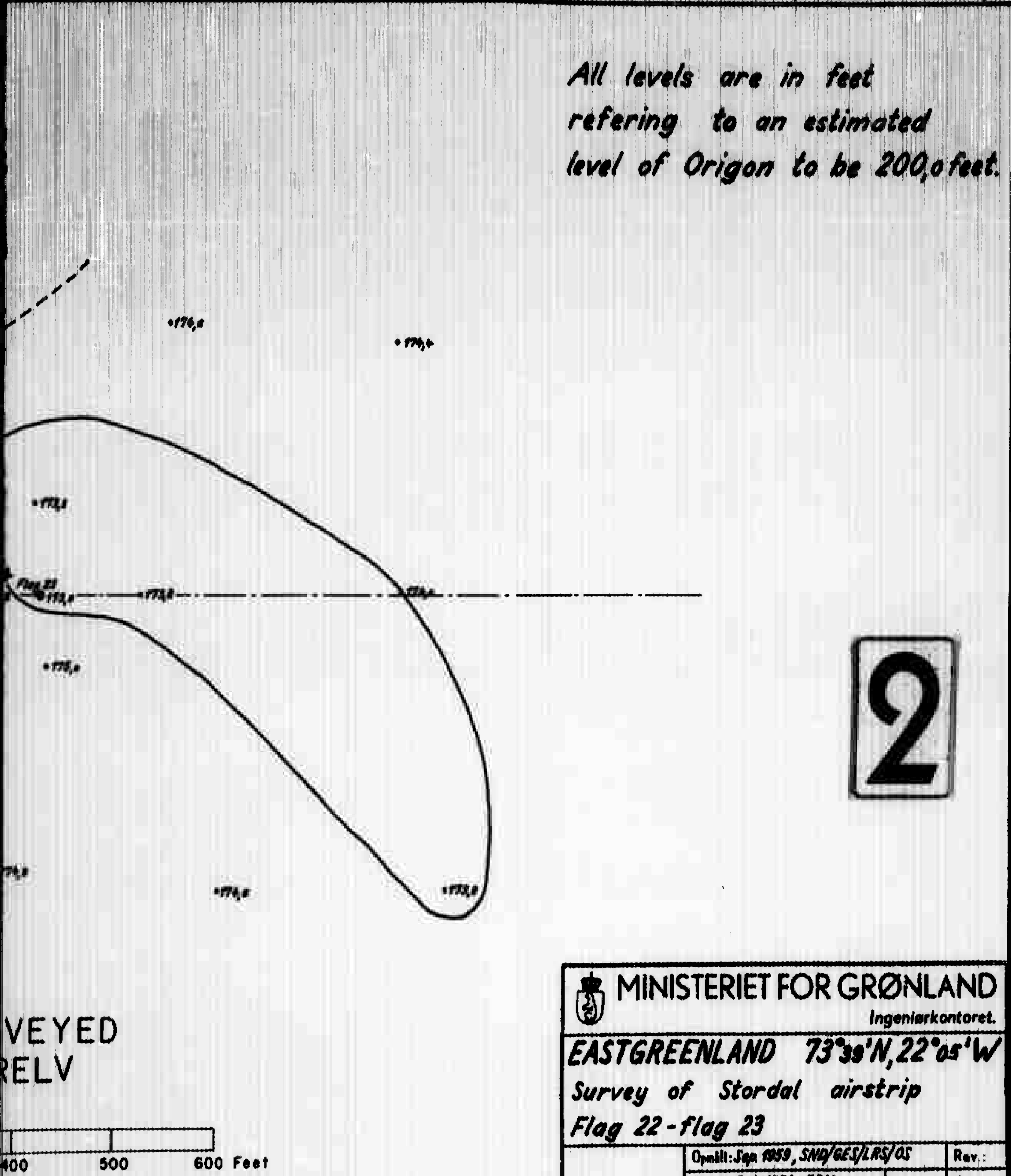

All levels are in feet refering to an estimated level of Origon to be 200,0 feet.
2
VEYED
RELV
400
500
600 Feet
MINISTERIET FOR GRØNLAND
Ingeniørkontoret.
EASTGREENLAND 73°39'N, 22°05'W
Survey of Stordal airstrip
Flag 22 - flag 23
Opmålt: Sep. 1959, SND/GES/LRS/OS
Tegnet: Oct. 1959, ESH
Rev.:
d.
SIGN.:
NR. 19283'04

Table 1. Index and summary of 33 landing sites investigated i[n]

AREA INVESTIGATED						METHOD OF SELECTION					SPECIFIC INVESTIGATIONS AND DATA COLL[ECTION]							
				REFERENCES			METHOD OF LOCATION OR EVALUATION OF SPECIFIC LANDING STRIPS						DETERMINATION OF LANDING STRIP LENGTH (letters denote relative reliability)			EVALUATION OF TOPOGRAPHY (relief and microrel[ief]) (letters denote rela[tive] reliability)		
													E	F	P	E	E	G
MAJOR AREAS OF INVESTIGATION	Areas and sites investigated	Key number on index map, map folios, photo packets	Location: coordinates of approximate center of area	USAF Aeronautical Approach Chart, 1:250,000	Aerial photos (* denotes 7P13C series)	Sites selected by office study of aerial photographs (other sites selected by reconnaissance in the field)	Low-level aerial reconnaissance (below 1000 feet)	Hasty ground reconnaissance (less than 1/2 man-hour; less than 2 man-hours on snow-covered areas)	Moderate ground reconnaissance (over 2 man-hours)	Detailed field investigation (30 man-hours or more)	Date of investigation (month/day, 1959)	Personnel SND: Stanley N. Davis, geologist, AINA JHH: Joseph H. Hartshorn, geologist, USGS ANK: Allan N. Kover, geologist, USGS LRS: Lowell R. Satin, geologist, AINA OS: Ole Skaerbo, civil engineer, Ministry of Greenland GES: George E. Stoertz, geologist, USGS	Taping or pacing (in conjunction with detailed field investigation)	Timed fly-over with helicopter (both directions)	Measurement on aerial photograph or estimation from air with little or no ground reconnaissance	Detailed topographic mapping	Aircraft landing test (by DO-27)	Ground photographs in conjunction with hasty ground reconnaissance
Hurry Fjord area	Kap Tobin	1	70°26'N 21°58'W	55 BIV	2-54, R10, 102-106 R *M38, 146-151 R		*	- - -	- - -	*	8/15-18	All 6	*	- - -	- - -	*		- - -
	Jaettedal	2	70°31'N 22°05'W	55 BIV	2-54, R10, 102-106 R *M38, 146-151 R		*	- - -	- - -	*	8/21	All 6	*	- - -	- - -	*	*	- - -
	Hvalrosbugt	3	70°30'N 21°59'W	55 BIV	2-54, R10, 102-106 R *[illegible]		- - -	- - -	*		8/18	JHH, ANK GES	*	- - -	- - -		*	*
South-western Jameson Land	Jameson Land Inland	4	70°43'30"N 23°53'W	55 BIV	*M28, 19-29 L; M35, 234-37 R; *M56, 51-54 L; 2-54, R10, 175-6 L	*	*				8/19*	SND, JHH, ANK			*			
	Jameson Land Coast	5	70°56'N 24°13'W	55 AIII	2-54, R1A, 20-21 L; *M35, 245-47 R; 2-54, R10, 165-167 R	*	*				8/19	SND, JHH, ANK			*			
Schuchert Elv area	Gurreholm	6	71°15'N 24°31'W	55 AII	*M35, 260-275 RLV 2-54, R1A, 50-51 V	*	*				8/19	JHH, GES			*			
	Nordøst Fjord	7	71°21'30"N 24°37'W	55 AII	*M35, 260-275 RLV 2-54, R1A, 50-51 V	*	*	- - -	*		8/19	JHH, GES	*	- - -	- - -			*
Eastern Milne Land	Charcot Havn	8	70°46'N 25°30'W	55 AIII	*M35, 196-198 R *M38, 196-199 R	*	*	*			8/20	JHH, GES			*			*
	Area north of Charcot Havn	9	70°51'N 25°28'W	55 AIII	*M35, 196-198 R *M38, 196-199 R	*	*				8/20	JHH, GES			*			
Northeastern Jameson Land	Carlsberg Fjord	10	71°27'N 22°38'W	55 BI	*M29, 96-98 LV *M76, 129-131 R		*				8/27	JHH, GES		*	- - -			
	Head of Nathorst Fjord	11	71°36'30"N 22°28'W	55 BI	*M29, 102-104 V *M29, 392-394 R	*	*				8/27	JHH, GES			*			
	Head of Fleming Fjord	12	71°35'N 23°04'W	55 BI	*M76, 136-139 RV; M28, 55-56 R; *M29, 105-107 L; 2-54, R5, 45-47 L	*	*				8/27	JHH, GES			*			
	Eastern Ørsted Dal	13	71°47'30"N 22°54'W	55 BI	*M28, 62-64 RV; M76, 145-7 RL; *M29, 113-114 L	*	*	*			8/27	JHH, GES			*			
	Central Ørsted Dal	14	71°47'N 23°22'W	55 BI	*M28, 62-64 RV; M76, 145-7 RL; *M29, 113-114 L	*	*				8/27	JHH, GES			*			
Kong Oscar Fjord area	Eastern Scoresby Land No. 1	15a	72°00'30"N 23°17'W	40 CIV	*M28, 71-73 R, 72-73 V *M29, 122-123 L	*	*				8/28	LRS, GES			*			
	Eastern Scoresby Land No. 2	15b	71°59'N 23°07'W	55 BI	*M28, 71-73 R, 72-73 V *M29, 122-123 L		*	*			8/28	LRS, GES		*	- - -			
	Eastern Traill Ø No. 1	16a	72°26'N 22°54'W	40 CIV	2-54, R5, 82-84 L, 80-83 V; *M29, 137-9 LV; *M28, 92-94 R	*	*				8/28	LRS, GES			*			
	Eastern Traill Ø No. 2	16b	72°25'N 22°45'W	40 CIV	2-54, R5, 82-84 L, 80-83 V; *M29, 137-9 LV; *M28, 92-94 R		*	*			8/28	LRS, GES		*	- - -			*
	Western Traill Ø	17a	72°31'30"N 24°01'W	40 DIII	*M66, 474-6 L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*	*			8/28	SND, ANK			*			
	Western Traill Ø	17b	72°31'N 23°57'W	40 DIII	*M66, 474-6 L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*				8/28	SND, ANK			*			
	Western Traill Ø	17c	72°30'N 23°59'W	40 DIII	*M66, 474-6L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*				8/28	SND, ANK			*			
	Kirschdalen	19	72°33'30"N 24°43'W	40 DIII	*M35, 327-329 R	*	*	*			8/28 8/30	SND, ANK, JHH, OS		*	- - -			*
	Polhem Dal	20	72°39'30"N 25°15'W	40 DIII	*M35, 327-337 L, 105-117 L; 7P14, M14, 316-317 L	*	*				8/30	JHH, OS			*			

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ry of 33 landing sites investigated in East Greenland, 1959 and 1960.

NVESTIGATIONS AND DATA COLLECTED OR AVAILABLE										RESULTS OF INVESTIGATIONS Potential value for aircraft landings						CONCLUSIONS				RECOMMENDATIONS (for emergency landing sites)			
RMINATION NDING STRIP H denote e reliability)		EVALUATION OF TOPOGRAPHY (relief and microrelief) (letters denote relative reliability)				EVALUATION OF SOIL CONDITIONS (letters denote relative reliability)				LANDING STRIP LENGTH		TOPOGRAPHY		SOIL STRENGTH IN SUMMER (at time of investigation)									
F	P	E	E	G	F	E	E	F	P														
Timed fly-over with helicopter (both directions)	Measurement on aerial photograph or estimation from air with little or no ground reconnaissance	Detailed topographic mapping	Aircraft landing test (by DO-27)	Ground photographs in conjunction with hasty ground reconnaissance	Low elevation hand-held aerial photographs in conjunction with low elevation aerial reconnaissance	Complete penetrometer tests at regular intervals (sufficient number to permit statistical analysis)	Test pit(s) and soil sampling on runway area or similar area in vicinity	Single cone penetrometer test or depth of penetration of helicopter tail wheel	Qualitative estimate of strength	Estimated minimum length in feet (runway plus one overrun)	Inferred reliability of length	Microrelief features that may be hazardous for planes	Inferred reliability of evaluation	Heaviest aircraft that could be safely supported during an emergency landing on preselected and marked strip (estimated)	Inferred reliability of evaluation	Summer season: suitability for emergency landings by light aircraft (DHC-4 Caribou or lighter)	Summer season: suitability for emergency landings by heavy cargo aircraft (C-130 or lighter)	Winter season: suitability for emergency landings when ground is frozen and/or snow-covered to depth of 6 inches	Suitability for hasty airfield construction	Mark strip for use as emergency landing site (t denotes sites recommended for use only in winter or if better sites are inaccessible)	Complete investigation on the ground; results of preliminary investigations show some potential value	Remove tentatively from further consideration; another site in the vicinity is superior	Remove from further consideration; investigations to date show little or no potential value
- - -	- - -	*		- - -	- - -	*	*	- - -	- - -	700	E	Cobbles, boulders	E	DHC-4	E	U	U	U	P			*	
- - -	- - -	*	*	- - -	- - -	*	*	- - -	- - -	1550	E	None	E	C-124	E	E	U	E	- - -	*			
- - -	- - -		*	*	- - -	*		- - -	- - -	900	E	None	E	C-124	E	G	U	E	- - -	- - -	- - -	- - -	- - -
	*				*				*	1000	P	Hummocks, boulders	F	None	P	U	U	U	U				*
	*				*				*	< 1000	P	Boulders, frost boils	F	None	P	U	U	U	U				*
	*				*				*	None	- - -	- - -	- - -	- - -	- - -	U	U	U	U				*
- - -	- - -			*	- - -	*	*	- - -	- - -	2500	F	Hummocks	G	C-130	E	U	P	F	U	t			
	*			*	*			*	- - -	4000	P	Channel scarps	P	None	F	U	U	F	U	t			
	*				*				*	3000	P	Channel scarps	P	None	P	U	U	F	U			*	
*	- - -				*				*	4000	F	Low hummocks	F	C-130	P	F	F	G	G	*	*		
	*				*				*	None	- - -	- - -	- - -	None	- - -	U	U	U	U				*
	*				*				*	< 1000	P	na	F	None	P	U	U	U	U				*
	*				*			*	- - -	5000	P	None	F	C-130	P	F	P	F	U			*	
	*				*				*	4000	P	None	F	C-130	P	F	P	F	P			*	
	*				*				*	± 700	P	na	F	DHC-4	P	P	U	F	U				*
*	- - -				*			*	- - -	3500	F	na	F	DHC-4	F	F	U	F	F			*	
	*				*				*	± 700	P	na	F	DHC-4	P	F	U	F	U				*
*	- - -			*	- - -			*	- - -	3000	F	None	G	C-130	F	F	F	G	F		*		
	*				*			*	- - -	5000	P	Cobbles	F	None	F	U	U	G	U			*	
	*				*				*	5000	P	Hummocks, swales	F	None	P	U	U	G	U			*	
	*				*				*	5000	P	Swales	F	None	P	U	U	G	U			*	
*	- - -			*	- - -			*	- - -	4500	F	Swales ? boulders ?	G	C-130	F	F	F	G	F	t	*		
	*				*				*	None	- - -	- - -	- - -	- - -	- - -	U	U	U	U				*

Hurry Fjord area	Kap Tobin	1	70°26'N 21°58'W	55 BIV	2-54, R10, 102-106 R *M38, 146-151 R		*	- - -	- - -	*	8/15-18	All 6	*	- - -	- - -	*		- -
	Jaettedal	2	70°31'N 22°05'W	55 BIV	2-54, R10, 102-106 R *M38, 146-151 R		*	- - -	- - -	*	8/21	All 6	*	- - -	- - -	*	*	- -
	Hvalrosbugt	3	70°30'N 21°59'W	55 BIV	2-54, R10, 102-106 R *M38, 146-151 R		- - -	- - -	*		8/18	JHH, ANK GES	*	- - -	- - -		*	*
South-western Jameson Land	Jameson Land Inland	4	70°43'30"N 23°53'W	55 BIV	*M28, 19-29 L; M35, 234-37 R; *M56, 51-54 L; 2-54, R10, 175-8 L	*	*				8/19*	SND, JHH, ANK			*			
	Jameson Land Coast	5	70°56'N 24°13'W	55 AIII	2-54, R1A, 20-21 L; *M35, 245-47 R; 2-54, R10, 165-167 R	*	*				8/19	SND, JHH, ANK			*			
Schuchert Elv area	Gurreholm	6	71°15'N 24°31'W	55 AII	*M35, 260-275 RLV 2-54, R1A, 50-51 V	*	*				8/19	JHH, GES			*			
	Nordøst Fjord	7	71°21'30"N 24°37'W	55 AII	*M35, 260-275 RLV 2-54, R1A, 50-51 V	*	*	- - -	*		8/19	JHH, GES	*	- - -	- - -			*
Eastern Milne Land	Charcot Havn	8	70°46'N 25°30'W	55 AIII	*M35, 196-198 R *M38, 196-199 R	*	*	*			8/20	JHH, GES			*			*
	Area north of Charcot Havn	9	70°51'N 25°28'W	55 AIII	*M35, 196-198 R *M38, 196-199 R	*	*				8/20	JHH, GES			*			
Northeastern Jameson Land	Carlsberg Fjord	10	71°27'N 22°38'W	55 BI	*M29, 96-98 LV *M76, 129-131 R		*				8/27	JHH, GES		*	- - -			
	Head of Nathorst Fjord	11	71°36'30"N 22°28'W	55 BI	*M29, 102-104 V *M29, 392-394 R	*	*				8/27	JHH, GES			*			
	Head of Fleming Fjord	12	71°35'N 23°04'W	55 BI	*M76, 136-139 RV; M28, 55-56 R; *M29, 105-107 L; 2-54, R5, 45-47 L	*	*				8/27	JHH, GES			*			
	Eastern Ørsted Dal	13	71°47'30"N 22°54'W	55 BI	*M28, 62-64 RV; M76, 145-7 RL; *M29, 113-114 L	*	*	*			8/27	JHH, GES			*			
	Central Ørsted Dal	14	71°47'N 23°22'W	55 BI	*M28, 62-64 RV; M76, 145-7 RL; *M29, 113-114 L	*	*				8/27	JHH, GES			*			
Kong Oscar Fjord area	Eastern Scoresby Land No. 1	15a	72°00'30"N 23°17'W	40 CIV	*M28, 71-73 R, 72-73 V [illegible]	*	*				8/28	LRS, GES			*			
	Eastern Scoresby Land No. 2	15b	71°59'N 23°07'W	55 BI	*M28, 71-73 R, 72-73 V *M29, 122-123 L		*	*			8/28	LRS, GES		*	- - -			
	Eastern Traill Ø No. 1	16a	72°26'N 22°54'W	40 CIV	2-54, R5, 82-84 L, 80-83 V; *M29, 137-9 LV; *M28, 92-94 R	*	*				8/28	LRS, GES			*			
	Eastern Traill Ø No. 2	16b	72°25'N 22°45'W	40 CIV	2-54, R5, 82-84 L, 80-83 V; *M29, 137-9 LV; *M28, 92-94 R		*	*			8/28	LRS, GES		*	- - -			*
	Western Traill Ø	17a	72°31'30"N 24°01'W	40 DIII	*M66, 474-6 L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*	*			8/28	SND, ANK			*			
	Western Traill Ø	17b	72°31'N 23°57'W	40 DIII	*M66, 474-6 L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*				8/28	SND, ANK			*			
	Western Traill Ø	17c	72°30'N 23°59'W	40 DIII	*M66, 474-6L; M28, 96-98 L; *M29, 144-5 L; M35, 323 R	*	*				8/28	SND, ANK			*			
	Kirschdalen	19	72°33'30"N 24°43'W	40 DIII	*M35, 327-329 R	*	*	*			8/28 8/30	SND, ANK, JHH, OS		*	- - -			*
	Polhem Dal	20	72°39'30"N 25°15'W	40 DIII	*M35, 327-337 L, 105-117 L; 7P14, M14, 316-317 L	*	*				8/30	JHH, OS			*			
Sofia Sund area	Southern Ymer Ø	21	73°03'N 24°37'W	40 DII	*M28, 279-282 R *M35, 349-353 R	*	*	*			8/30	ANK, GES		*	- - -			*
	Central Ymer Ø	22	73°07'N 24°12'W	40 DII	*M66, 446-447 L *M28, 278-280 L, 124-126 L	*	*				8/30	ANK, GES			*			
	Northern Geographical Society Ø	23	73°02'N 22°50'W	40 CI	*M29, 161-162 LV, 335-336 R; 2-54, R5, 110-114 RV	*	*	*			8/30	ANK, LRS			*			
Hold With Hope and vicinity	Loch Fyne	24a	73°38'N 21°48'W	40 CI	*M29, 310-312 L; M27, 322-4 L; *M57, 344-9 L; 2-54, R5, 137-42 L	*	*	*			8/30	JHH, GES			*			
	Storelv	24b	73°39'N 22°02'W	40 CI	*M27, 322-324 LV *M29, 310-312 LV	*	*	- - -	- - -	*	8/30-9/7	All 6 ('59) All 4 ('60)	*	- - -	- - -	*		- -
	Storelv No. 2	24b	73°39'N 22°05'W	40 CI	*M27, 322-324 LV *M29, 310-312 LV					*	8/31-9/7	All 4 ('60) GES ('59)	*	- - -	- - -		*	*
	Storelv No. 3	24b	73°41'N 22°07'W	40 CI	*M27, 322-324 LV *M29, 310-312 LV				*		8/31-9/7	All 4 ('60) LRS, GES ('59)	*	- - -	- - -			*
	Storelv No. 4	24b	73°41'N 22°02'W	40 CI	*M27, 322-324 LV *M29, 310-312 LV				*		8/31-9/7	All 4 ('60) GES ('59)	*	- - -	- - -			*
	Storelv short landing strip	24b	73°40'N 22°04'W	40 CI	*M27, 322-324 LV *M29, 310-312 LV			- - -	*		8/31-9/7	All 6	*	- - -	- - -		*	- -
	Østersletten	25	73°34'N 20°34'54"W	40 CI	2-54, R5, 155-7 V; *M54, 194-5 RV; *M57, 310-12 RLV, 339-40 R; M58, 8-10 LVR	*	*	*			8/30	SND			*			

KEY:

*	Affirmative	E	Excellent reliability or suitability	SND	Stanl
	Negative	G	Good reliability or suitability	JHH	Josep
- - -	Not applicable	F	Fair reliability or suitability	ANK	Allan
na	Not available	P	Poor reliability or suitability	DWK	Dona
c	Conditional	U	Unsuitable	CEM	Carlt

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---	*	*	---	---	*	*	---	---	1550	E	None	E	C-124	E	E	U	E	---	*			
---		*	*	---	*		---	---	900	E	None	E	C-124	E	G	U	E	---	---	---	---	---
*				*				*	1000	P	Hummocks, boulders	F	None	P	U	U	U	U				*
*				*				*	< 1000	P	Boulders, frost boils	F	None	P	U	U	U	U				*
*				*				*	None	---	---	---	---	---	U	U	U	U				*
---			*	---	*	*	---	---	2500	F	Hummocks	G	C-130	E	U	P	F	U	t			
*			*	*			*	---	4000	P	Channel scarps	P	None	F	U	U	F	U	t			
*				*				*	3000	P	Channel scarps	P	None	P	U	U	F	U			*	
---				*				*	4000	F	Low hummocks	F	C-130	P	F	F	G	G	*	*		
*				*				*	None	---	---	---	None	---	U	U	U	U				*
*				*				*	< 1000	P	na	F	None	P	U	U	U	U				*
*				*			*	---	5000	P	None	F	C-130	P	F	P	F	U	.		*	
*				*				*	4000	P	None	F	C-130	P	F	P	F	P			*	
*				*				*	± 700	P	na	F	DHC-4	P	P	U	F	U				*
---				*			*	---	3500	F	na	F	DHC-4	F	F	U	F	F			*	
*				*				*	± 700	P	na	F	DHC-4	P	F	U	F	U				*
---			*	---			*	---	3000	F	None	G	C-130	F	F	F	G	F		*		
*				*			*	---	5000	P	Cobbles	F	None	F	U	U	G	U			*	
*				*				*	5000	P	Hummocks, swales	F	None	P	U	U	G	U			*	
*				*				*	5000	P	Swales	F	None	P	U	U	G	U			*	
---			*	---			*	---	4500	F	Swales ? boulders ?	G	C-130	F	F	F	G	F	t	*		
*				*				*	None	---	---	---	---	---	U	U	U	U				*
---			*	---			*	---	5000	F	Hummocks, boulders	G	C-130	F	F	F	G	F	*	*		
*				*				*	1000	P	na	F	DHC-4	P	F	U	F	U				*
*				*			*	---	3500	P	na	F	None	F	U	U	P	U				*
*				*			*	---	4000	P	na	F	None	F	U	U	F	U			*	
---	*		---	---	*	*	---	---	2500	E	Low hum-mocks	E	C-130	E	F	F	F	G	*	*		
									4000	E	Hummocks, frost cracks											
---		*	*	---	*	*		*	2800	E	Low hummocks	E	C-130	E	G	F	F	G		*		
---			*	---		*		*	3800	G	Hummocks, swales	E	C-130	E	G	F	F	G		*		
---			*	---		*		*	2000	P	Hummocks, swales, frost mounds	E	C-130	E	U	U	U	P		*		
---		*	---	---		*	*	---	750	F	None	E	DHC-4	G	G	U	G	U				
*				*			*	---	4000	P	na	F	None	F	U	U	P	U				*

SND Stanley N. Davis (1959)
JHH Joseph H. Hartshorn (1959, 1960)
ANK Allan N. Kover (1959)
DWK Donald W. Klick (1960)
CEM Carlton E. Molineux (1960)
LRS Lowell R. Satin (1959)
OS Ole Skaerbo (1959, 1960)
GES George E. Stoertz (1959)
(boxed) Data or evaluations based on investigations from 12 July to 22 July 1960; all other based on 1959 investigations

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